Digitized by the Internet Archive
in 2011 with funding from
University of Toronto

http://www.archive.org/details/proceedingsofa1912amer

DOW R. GWINN

TERRE HAUTE, IND.

PROCEEDINGS

OF THE

THIRTY-SECOND ANNUAL CONVENTION

OF THE

AMERICAN WATER WORKS ASSOCIATION

HELD AT

LOUISVILLE, KENTUCKY, JUNE 3-7, 1912

PUBLISHED BY THE ASSOCIATION

126362
18 | 2 | 13

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its Proceedings

TD
201
A5 12
1912

COMPOSED AND PRINTED AT THE
WAVERLY PRESS
BY THE WILLIAMS & WILKINS COMPANY
BALTIMORE, U. S. A

OFFICERS 1912-1913

President

DOW R. GWINN, President Water Company.....Terre Haute, Ind.

First Vice-President

ROBERT J. THOMAS, Superintendent Water Works.....Lowell, Mass.

Second Vice-President

JOHN A. AFFLECK, President Water Board.....Harrisburg, Pa.

Third Vice-President

GEORGE G. EARL, General Superintendent Sewerage and Water Board, New Orleans, La.

Fourth Vice-President

THEODORE A. LEISEN, Chief Engineer Water Department..Louisville, Ky.

Fifth Vice-President

CHARLES R. HENDERSON, Manager Water Co.....Davenport, Iowa

Finance Committee

H. E. KEELER, Chairman, President Rogers Park Water Company, 633 The Rookery,.....Chicago, Ill.

LEONARD METCALF, Consulting Engineer, 14 Beacon Street, Boston, Mass.

LESLIE C. SMITH, Water Works Accountant, 2118 East 40th Street, Cleveland, Ohio

Secretary-Treasurer

JOHN M. DIVEN, 47 State Street.....Troy, N. Y.

Executive Committee

DOW R. GWINN,
ROBERT J. THOMAS,
JOHN A. AFFLECK,
GEORGE G. EARL,
THEODORE A. LEISEN,
CHARLES R. HENDERSON,
H. E. KEELER,
LEONARD METCALF,
LESLIE C. SMITH,
JOHN M. DIVEN,
ALEX. MILNE.

The Thirty-third Annual Convention will be held at Minneapolis, Minn.

STANDING AND SPECIAL COMMITTEES

PUBLICATION

H. E. Keeler, Chairman, President Rogers Park Water Company, 633 The Rookery.....Chicago, Ill.
Dabney H. Maury, Consulting Engineer, 1137 Monadnock Block, Chicago, Ill.
Edward Bartow, Director Illinois State Water Survey.....Urbana, Ill.
Leslie C. Smith, Water Works Accountant.....Cleveland, O.
J. M. Diven, Secretary, 47 State Street.....Troy, N. Y.

ELECTROLYSIS

Dabney H. Maury, Chairman, Consulting Engineer, 1137 Monadnock Block, Chicago, Ill.
J. Waldo Smith, Chief Engineer, Board Water Supply, 209 Broadway, New York, N. Y.
Prof. Albert F. Ganz, Stevens Institute.....Hoboken, N. J.

FIRE PROTECTION

R. J. Thomas, Chairman, Superintendent Water Department. Lowell, Mass.
F. W. Shepperd, Fire and Water Engineering, 136 West 22d Street, New York, N. Y.
George Houston, Water Commissioner.....Kalamazoo, Mich.
F. C. Kimball, General Manager Water and Light Company...Summit, N. J.
A. W. Cuddeback, Superintendent Water Works.....Paterson, N. J.

REVISION OF STANDARD SPECIFICATIONS FOR CAST IRON PIPE AND SPECIALS

John H. Gregory, Chairman, Consulting Engineer, 170 Broadway, New York, N. Y.
Leonard Metcalf, Consulting Engineer, 14 Beacon Street .....Boston, Mass.
Walter Wood, 400 Chestnut Street.....Philadelphia, Pa.
W. H. Randall, Superintendent Maintenance Water Department Toronto, Ont., Canada.

STANDARD SPECIFICATIONS FOR WROUGHT IRON PIPE

A. A. Reimer, Chairman, Engineer Water Department....East Orange, N. J.
Robert Spurr Weston, Chemist and Bacteriologist, 14 Beacon Street, Boston, Mass.
Emil Kuichling, Civil Engineer, 52 Broadway.....New York, N. Y.
T. C. Hatton, Consulting Engineer, 302 Equitable Building..Wilmington,Del.
George C. Whipple, Consulting Engineer, 103 Park Ave.....New York, N. Y.

UNIFORM ANNUAL REPORTS AND ACCOUNTS

Albert H. Wehr, Chairman, 100 W. Fayette Street.....Baltimore, Md
John Caulfield, Secretary Water Board.....St. Paul, Minn.
H. M. Ely, Superintendent Danville Water Company.....Danville, Ill.
W. S. Kuhn, General Manager Water Works and Guarantee Company, Pittsburgh, Pa.
J. W. Ackerman, Superintendent Water Board.....Auburn, N. Y.

DEPRECIATION

Leonard Metcalf, Chairman, Consulting Engineer, 14 Beacon Street, Boston, Mass.
John W. Alvord, Consulting Engineer, 1417–18 Hartford Building, Chicago, Ill.
Daniel W. Mead, Professor Hydraulic Engineering, 401 State Street, Madison, Wis.
C. B. Salmon, President and Treasurer Water, Gas and Electric Company, Beloit, Wis.
Wynkoop Kiersted, Consulting Engineer, Water Works Building, Kansas City, Mo.
J. N. Hazelhurst, Consulting Engineer, 905 Chandler Building..Atlanta, Ga.
W. F. Wilcox, Central Water Works.....Ensley, Ala.

SPECIAL COMMITTEE ON NATIONAL BUREAU OR DEPARTMENT OF HEALTH

Theodore A. Leisen, Chairman, Chief Engineer Water Company, Louisville, Ky.
M. N. Baker, Associate Editor *Engineering News*.....New York, N. Y.
John M. Goodell, Editor *Engineering Record*, 239 W. 39th Street, New York, N. Y.
Morris Knowles, Chief Engineer Bureau of Filtration.....Pittsburgh, Pa.

PERMANENT HEADQUARTERS

George H. Felix, Chairman, 138 North Main Street.....Reading, Pa.
William P. Mason, Professor of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y.
Richard U. Sherman, President Consolidated Water Company....Utica, N. Y.
Allen Hazen, Consulting Engineer, 103 Park Avenue.....New York, N. Y.
Rudolph Hering, Hydraulic and Sanitary Engineer, 170 Broadway, New York, N. Y.

INCORPORATION OF ASSOCIATION

John W. Alvord, Chairman, Consulting Engineer, 1417–18 Hartford Building, Chicago, Ill.
Alexander Milne, Superintendent Water Works, St. Catharines, Ont., Canada
H. E. Keeler, President Rogers Park Water Company, 633 The Rookery, Chicago, Ill.
J. M. Diven, Secretary, 47 State Street.....Troy, N. Y.

REVISION OF CONSTITUTION

Dabney H. Maury, Chairman, Consulting Engineer, 1137 Monadnock Block.....Chicago, Ill.
Leonard Metcalf, Consulting Engineer, 14 Beacon Street.....Boston, Mass.
Theodore A. Leisen, Chief Engineer Water Company.....Louisville, Ky.
Charles R. Henderson, Manager Water Co., 114 W. Third Street, Davenport, Ia.
Edward Bartow, Director Illinois State Water Survey.....Urbana, Ill.

STANDARD SPECIFICATIONS FOR HYDRANTS AND VALVES

B. C. Little, Chairman, Superintendent Water Works .....Rochester, N. Y.
Morris R. Sherrerd, Chief Engineer Street and Water Commission, Newark, N. J.
James H. Caldwell, C.E.,.....Troy, N. Y.
Stuart Wood, 400 Chestnut Street.....Philadelphia, Pa.
J. M. Diven, Secretary, 47 State Street.....Troy, N. Y.

WATER CONSUMPTION

T. C. Phillips, Chairman, Water Works Engineer, 404 City Hall, Chicago, Ill.
J. N. Chester, Hydraulic Engineer.....Pittsburgh, Pa.
Alexander Potter, Consulting Engineer, 114 Liberty Street, New York, N. Y.
E. E. Davis, Superintendent Water Department.....Richmond, Va.
Henry J. Montoulieu, Superintendent Water Department....Havana, Cuba

TABULATION OF RATES AND OTHER INFORMATION

F. C. Jordan, Chairman, Secretary Indianapolis Water Company, Indianapolis, Ind.
A. P. Folwell, Editor *Municipal Journal*.....New York, N. Y.
H. F. Dunham, Civil Engineer, 220 Broadway.....New York, N. Y.
F. H. Shaw, Civil Engineer, 503 Woolworth Building.....Lancaster, Pa.
George G. Earl, General Superintendent Sewerage and Water Board, New Orleans, La.

TABLE OF CONTENTS

Officers 1912–1913 iii
Standing and Special Committees v
List of Illustrations xiii
List of Tables and Diagrams xv
Ancient and Modern Water Works. By Edward Wegman 1
Floor Area Unit as a Basis for Estimating Consumption. By William W. Brush 35
Discussion by:
T. C. Phillips 42, 45, 46
William W. Brush 42, 43, 44, 46
Alexander Potter 43
Edward S. Cole 43, 45
More Than Fifty Years Reminiscences in Water Works. By H. G. H. Tarr 47
Discussion by:
John Caulfield 55
Stuart Wood 56
William Schwanhauser 59
J. M. Diven 60
Organization of Bureau of Water Supply, City of New York. By I. M. deVarona 61
Discussion by:
Henry B. Machen 74
The Philosophy of Purchasing Supplies. By Elihu Cunyngham Church 75
Discussion by:
Harrington Emerson 80
The Principles of Efficiency Applied to Water Works. By Harrington Emerson 81
The Value of a Continuous Settling Basin, and a Discussion of the Economic Principles of Design of Such Reinforced Concrete Structures. By Alexander Potter 89
Discussion by:
Edward Wegman 109
W. F. Wilcox 111
Dow R. Gwinn 112
Alexander Potter 112, 113, 115
C. B. Salmon 112
Edgar B. Kay 112, 115
F. H. Shaw 115
Turbine Driven Centrifugal Pumps for water Works Service. By W. O. Beyer 117

Discussion by:
Theodore Leisen.... 124
J. N. Chester....124, 138, 139
L. E. Strothman....128, 136
Edward S. Cole.... 133
Henry L. Lyon.... 133
H. F. Dunham.... 134
J. S. Fulton....134, 136
E. E. Davis.... 137
Alexander Potter.... 138
C. B. Salmon.... 138
J. P. Berry....138, 139
W. F. Wilcox.... 139

Progress in Adoption of the National Standard Hose Coupling and Hydrant Fittings for Public Fire Service. By F. M. Griswold... 141

Laying Water Main Under Streams, or How We Crossed two Streams with Ward Pipe at Rome, Georgia. By M. L. Worrell.... 147
Discussion by:
John A. Kienle.... 153
M. L. Worrell.... 155

Electrolysis from Stray Electric Currents. By Albert F. Ganz.... 159
Discussion by:
Edward Wegman.... 198
Albert F. Ganz....198, 199, 201
E. H. Breidenbach.... 199
A. A. Reimer.... 199

Water Softening at Owensboro, Ky. By E. H. Breidenbach.... 203
Discussion by:
E. H. Breidenbach.... 218

Chlorination at Cleveland, Ohio. By D. D Jackson.... 219

Hypochlorite Sterilization at Kansas City, Missouri. By S. Y. High.... 225
Discussion by:
Dow R. Gwinn....232, 240, 242, 243
J. S. Butler.... 232
George G. Kennedy....232, 238
J. L. Leal.... 233
D. D. Jackson....237, 238, 239
A. Prescott Folwell.... 237
F. B. Leopold....237, 238
F. H. Stover....237, 240
Edward Bartow.... 240
W. F. Wilcox.... 240
M. N. Baker.... 241
John A. Kienle.... 241
W. W. DeBerard.... 242
E. E. Davis.... 243

The Cost of Leaks: Does it Pay to Stop Them. By Edward S. Cole.. 245
Discussion by:
J. N. Chester....251, 252

Discussion by:
Alexander Potter.... 251
A. A. Reiner....252, 254
Edward S. Cole.... 253
F. H. Shaw.... 253
William Luscombe.... 253
T. C. Phillips.... 253
Methods and Cost of Leakage Survey at Lancaster, Pennsylvania. By F. H. Shaw.... 257
Discussion by:
Dow R. Gwinn....262, 267
Edward S. Cole.... 262
William Luscombe.... 262
F. H. Shaw....262, 266, 267
R. J. Thomas....262, 266
T. C. Phillips.... 263
John A. Kienle....263, 266
George G. Kennedy....264, 266
A. A. Reimer.... 265
To What Degree Must Sewage be Purified. By Chester G. Wigley... 269
Discussion by:
Chester G. Wigley.... 283
Dow R. Gwinn.... 283
F. B. Leopold.... 284
M. N. Baker.... 284
Alexander Potter.... 285
Phenomenal Growth of the Water Works of Edmonton, Alberta. By A. Maclean.... 289
Discussion by:
A. A. Reimer.... 292
A. Maclean....292, 293, 294, 296, 300
J. M. Diven.... 292
V. A. Thompson....292, 293, 294, 296, 297, 298
F. J. Connor....292, 294, 297
R. L. Clemmitt.... 295
W. F. Wilcox.... 295
J. H. Fewell.... 296
E. H. Breidenbach.... 296
Dow R. Gwinn.... 297
W. F. Montfort....297, 298
E. E. Davis....298, 300
Ice Troubles at Buffalo. By Henry L. Lyon.... 301
Discussion by:
A. Maclean.... 303
A Method of Increasing the Depth of A Large Wooden Settling Tank. By A. H. Meyers.... 305
A Reliable Presumptive Quantitative Test for B. Coli. By S. T. Powell.... 307
Forty-Eight Inch Wood Stave Force Main Built for the Water Department of Atlantic City. By L. VanGilder.... 313
Experiences....317

Discussion by:
W. F. Wilcox....317, 320, 321
Leonard Bauer....318
M. L. Worrell....318
Robert L. Clemmitt....319
F. H. Shaw....319, 320, 324
William R. Young....319, 322, 323
Dow R. Gwinn....319, 322, 323
John Caulfield....320
E. E. Davis....320
J. M. Diven....321, 323
C. E. Abbott....322
A. A. Reimer....324

A Discussion of Depreciation and a Comparison of Rates and Bookkeeping Methods of Municipally and Privately Owned Water Works....325

Discussion by:
John W. Alvord....325, 329, 330, 333, 334
J. M. Chester....327, 329, 330, 331, 338
H. B. Morgan....328, 336, 338, 342, 343, 345
Leslie C. Smith....328, 333, 334, 338
W. S. Cramer....329
J. Walter Ackerman....329, 330, 332, 340
Stuart Wood....332
Theodore A. Leisen....335, 336
J. Davis Barnet....338
V. A. Thompson....340
H. E. Keeler....340
Alexander Potter....341, 346
Dow R. Gwinn....342, 344
T. J. Powell....342, 343
W. F. Wilcox....345

Question Box....349
Street Sprinkling by Street Car Companies....350
Purchase of Coal by B.t.u....351
Incineration Plants for Power....352
Regulation of Private Fire Services....359
Experiences with Private Fire Services....361
Effect of Cold Weather on Water Consumption....389
Charge for Private Fire Services....411
Control of Private Fire Services....415
Charge for Reading and Maintaining Meters....416
Increasing Supply from Flowing Wells....419
Experience with Lead Flange Connections....420

Obituary....425

Index, Subject....429
Authors....461

Advertisements....1a-52a

Index to Advertisements....467

Classified Index to Advertisements....469

ILLUSTRATIONS

FRONTISPIECE

Portrait of President—Mr. Dow R. Gwinn.

ANCIENT AND MODERN WATER WORKS

Aqueduct of Athens 3
Marcian Aqueduct 3
Map of Location of Roman Aqueducts 5
Marcian Aqueduct 7
At the Aurelian Wall 7
Claudian Aqueduct 10
In the Campagna 11
At the Porta Maggiore 11
Sections of Roman Aqueducts 13
Roman Level 15
Roman Lead Pipes 15
Pont Du Gard 17
Aqueduct of Segovia 18
Cistern of 1001 Columns in Constantinople 19
Old Map of New York ..... inset facing 20
Vicinity of Collect Pond, New York, in 1793 ..... inset following 20
Section of New York Aqueducts 22
High Bridge 23
Terminal Gate House in Central Park 25
Pipe Line in Convent Avenue 25
Catskill Watershed 28
Profile Catskill Aqueduct 29
Section of Dikes and Aqueducts 30
Comparative Sections of Aqueducts 31
Hudson River Crossing 32

FLOOR AREA BASIS FOR ESTIMATING CONSUMPTION

Districts in Manhattan in which consumption has been determined on floor area basis ..... inset following 39

MORE THAN FIFTY YEARS REMINISCENCE IN WATER WORKS

Call for first convention ..... inset opposite 54

ORGANIZATION OF BUREAU OF WATER SUPPLY, CITY OF NEW YORK

Distribution System all Boroughs ..... inset following 60
Sources of Water Supply ..... inset following 60
Organization Adopted ..... inset following 68
Organization of Bureau of Water Supply 69

THE VALUE OF A CONTINUOUS SETTLING BASIN, AND A DISCUSSION OF THE ECONOMIC PRINCIPLES OF DESIGN OF SUCH REINFORCED CONCRETE STRUCTURES

Plan and section of Settling Basin ..... inset following 89
Plan and Section of Walls ..... inset following 89

The Value of a Continuous Settling Basin—Continued
South Wall Showing Steel Reinforcement ... 97
Finished South Wall ... 97
Section Showing Buttress Reinforcement ... inset following 98
Forces Acting in Walls ... 99
Southwest Corner of Basin Showing Steel Reinforcement ... 100
Forces, Except Earth Pressure, Acting on Tank ... 102
Forces Acting on Counterfort ... 103
Southwest Corner of Basin Finished ... 105
Interior View Looking West ... 106
Interior View During Construction ... 107
Electrolysis from Stray Electric Currents
Typical Potential Survey ... 170
Permanent Electrical Test Wires ... 171
Typical Current Survey ... 172
Service Pipe Negative to Trolley Rails destroyed by Currents Flowing to Cable Sheaths ... 179
Section of Macallen Insulating Joint ... 187
Section of Insulating Flanged Joint ... 188
Relative leakage Currents with Various Return Circuit Conditions ... 190
Water Softening at Owensboro, Kentucky
Complete Plant Looking Northward ... 204
Sectional Plan ... 205
Longitudinal Section ... 205
Section Through Settling Basin ... 206
West Basin Before Filling ... 207
Inlet Weir Box Showing Sutro Weirs ... 209
Longitudinal Section of Chemical and Mixing Tanks ... 210
Chemical Regulator ... 211
Slacking Chemical and Softening Tank ... 212
Chemical Regulator ... 213
Softening Tank Room ... 214
Hypochlorite Sterilization at Kansas City, Missouri
Temporary and Permanent Plants ... 227
Pasting Tank, Plan ... 228
Pasting Tank, Section ... 229
Plan and Section of Plant ... inset opposite 230
Method and Cost of Leakage Survey at Lancaster, Pennsylvania
Measuring Apparatus ... 259

TABLES AND DIAGRAMS

Ancient and Modern Water Works

Roman Aqueduct Described by Frontinus..... 9
Water Supply of Modern Rome..... 20
Storage Reservoirs in Croton Watershed..... 26
Storage in Lakes and Ponds in Croton Watershed..... 26

Floor Area Basis for Estimating Consumption

Water Consumption in Typical Buildings..... 37
Gaugings 1902–03 and 1911..... 38
Units Adopted for Estimating Consumption..... 40
Water Consumption in Typical Districts..... 41

Organization of Bureau of Water Supply, City of New York

High Pressure Service System..... 66
Force and Salary Account..... 71
Work under Chief Engineer in 1902 and 1912..... 72

Steam Turbines and Centrifugal Pumps

Table: Comparison of Cost of Crank and Fly Wheel and Centrifugal Pumps..... 120
Comparative Cost Chart..... 121

Laying Water Mains under Streams or How We Crossed two Streams with Ward Pipe at Rome, Georgia

Specials for Connecting Ward and Regular Pipe..... 148
Plan of Float..... 149
Views of Apparatus..... 151

Electrolysis from Stray Electric Currents

Diagram of Single Trolley Electric Railway showing Path of Current..162
Diagram showing Stray Railway Currents..... 165
Diagram of Simultaneous Current Measurement where there is No Change in Current between Stations..... 173
Diagram of Simultaneous Current Measurement where there is Change in Current between Stations..... 174
Diagram of Stray Currents Averaged from Bristol Twenty-Four Hour Records..... 175
Diagram showing Stray Currents Leaving Water Main in Negative District..... 178
Diagram showing Stray Currents Causing Fire Hazard..... 180
Diagram showing Increased Danger from Bonding Pipes to Rails.... 183
Diagram of Single Trolley showing Path of Current and Assumed Rail Potentials..... 189
Diagram showing Trolley Lines Radiating Out from Power Station With and Without Insulated Return Feeders..... 193
Table for Determining Current Flow on Iron Pipe..... 197

Water Softening at Owensboro Kentucky
Table: Mineral Analysis of Raw and Softened Water..... 208
Table: Bacterial Analysis..... 215
Table: Summary of Operation..... 217
Chlorination at Cleveland, Ohio
Table: Effect of Temperature on Chlorination..... 221
Diagram: Monthly Typhoid Death Rate..... 223
Discussion, Hypochlorite Sterilization
Table: Hypochlorite Treatment at Gettysburg, Pennsylvania..... 233
Table: Bacterial Results, Boontown, N. J..... 235
Table: Summary of Results of Filtration at Little Falls, New Jersey 236
Charts Showing Bacterial Efficiency at Wilmington, Delaware
insets opposite 240
The Cost of Leaks: Does it Pay to Stop Them?
Table: Water Consumption of American Cities
Diagram inset opposite 348
Table: Water Consumption of British Cities..... 348
Discussion: Cost of Waste
Diagram showing Distribution of Water Consumption in Chicago.... 255
A Reliable Presumptive Quantitative Test for B. Coli
Table: Showing Results of Test..... 308
Question Box
Current and Time Required to Thaw Water Pipes by Electricity.... 398

ANCIENT AND MODERN WATER WORKS[1]

By Edward Wegmann

From the remotest ages works were undertaken to obtain ample supplies of water for domestic purposes and for irrigation. In Egypt these works consisted of canals for diverting water from the Nile. The only aqueduct of which ruins are found in that country is near Cairo and the date of its construction is uncertain. Water was raised from the River Nile by means of chain pumps to a height of 92 feet, and was conveyed through a masonry conduit, about 2 miles long, having a fall of about 23 feet. Near the end of the aqueduct three pump wells were sunk and the water was raised by chain pumps in three lifts (respectively 29, 59 and 130 feet) to the Citadel of Cairo. The total height above the Nile to which the water was raised was 310 feet.

In Asia Minor remains of ancient conduits, consisting generally of earthen or stone pipes, are found in different places. Jerusalem was partly supplied with water by a line of earthen pipes, about 10 inches in diameter, which brought water from reservoirs near Bethlehem, known as the pools of Solomon, to the temple. Each pipe was encased in two stone blocks, cut to fit the pipe. The blocks containing the pipes were placed on foundations of stone work and covered with rubble masonry, laid in mortar. This pipe line, which was about 12 miles long, terminated just west of the temple, for which the water was especially needed. For the greater part, the pipes were laid below the surface, but, in crossing the plain at Jerusalem, the pipes had to be placed above ground. Remains of this old pipeline, which was probably constructed in Solomon's time (about 1000 B. C.), are still to be seen.

The city of Laodicea in Phrygia was supplied with water by an aqueduct, about 5 miles long, which was probably built about 260 B. C. The crossing of a deep valley on the line of this conduit was effected by an inverted siphon, consisting of two lines of stone pipes,

[1] This paper was presented by the author at the annual convention in Louisville as a lecture, illustrated by lantern slides, showing views of water works beginning with the aqueduct of Athens, built about 500 B.C., and finishing with the Catskill Water Works, now under construction for the city of New York.

respectively 9 and 10 inches in diameter, fitted together in hub and spigot fashion. Each pipe had a vent hole for permitting air to escape as the pipe was filled with water. The vent holes were eventually filled with mortar. At the deepest point the siphon was under a head of 130 feet.

At Patara in Syria a siphon of stone pipes was carried on an aqueduct wall across a ravine, about 200 feet wide and 250 feet deep at the lowest point. This structure, known as the aqueduct of Patara, is one of the finest ruins of early Greek construction. It is still in a very good state of preservation. The two faces of the wall are formed of large, irregular blocks of stone, and the space between the faces is filled with sand, on which the stone pipes were laid. The height of the wall is considerably less than the depth of the ravine, as the wall descends rapidly on either side, being horizontal only at the center of the ravine. The siphon conduit consisted of stone blocks, each containing about 3 cubic feet, which were bored through the center to a diameter of about 13 inches. Each block had an annular projection at one end, and a recess about 3 inches deep at the other, the blocks being thus connected by "hub and spigot" joints. The joints were filled with cement and were made still more secure by uniting the blocks by iron clamps, fastened into holes by pouring lead. At intervals of about 20 feet air vents, 7 inches in diameter, were provided. Broken earthen pipes were found along the wall and were probably used originally, and replaced later by the stone pipes. The siphon is continued by a canal, covered with large stone slabs.

In various places in Asia Minor there are ruins of masonry aqueducts, but these were all built by the Romans.

In Greece we find some old aqueducts, generally built below ground, in order to conceal them from an enemy in time of war. About the oldest of these works is the Aqueduct of Athens, (Plate I) built about 500 B. C. The aqueduct is formed of stone blocks, laid dry, and is just about large enough to permit a man to crawl through it. Pipe lines similar to those described above are found in different places in Greece.

The greatest water works of ancient times were built by the Romans. Many ruins of their aqueducts, some of them remarkably well preserved, are to be seen in Italy, Spain, France, Germany, Turkey, and also in Africa and Asia Minor. About two hundred ruins of such works have been found. The most important are those that supplied Rome. We shall describe briefly the water works of Ancient Rome.

AQUEDUCT OF ATHENS

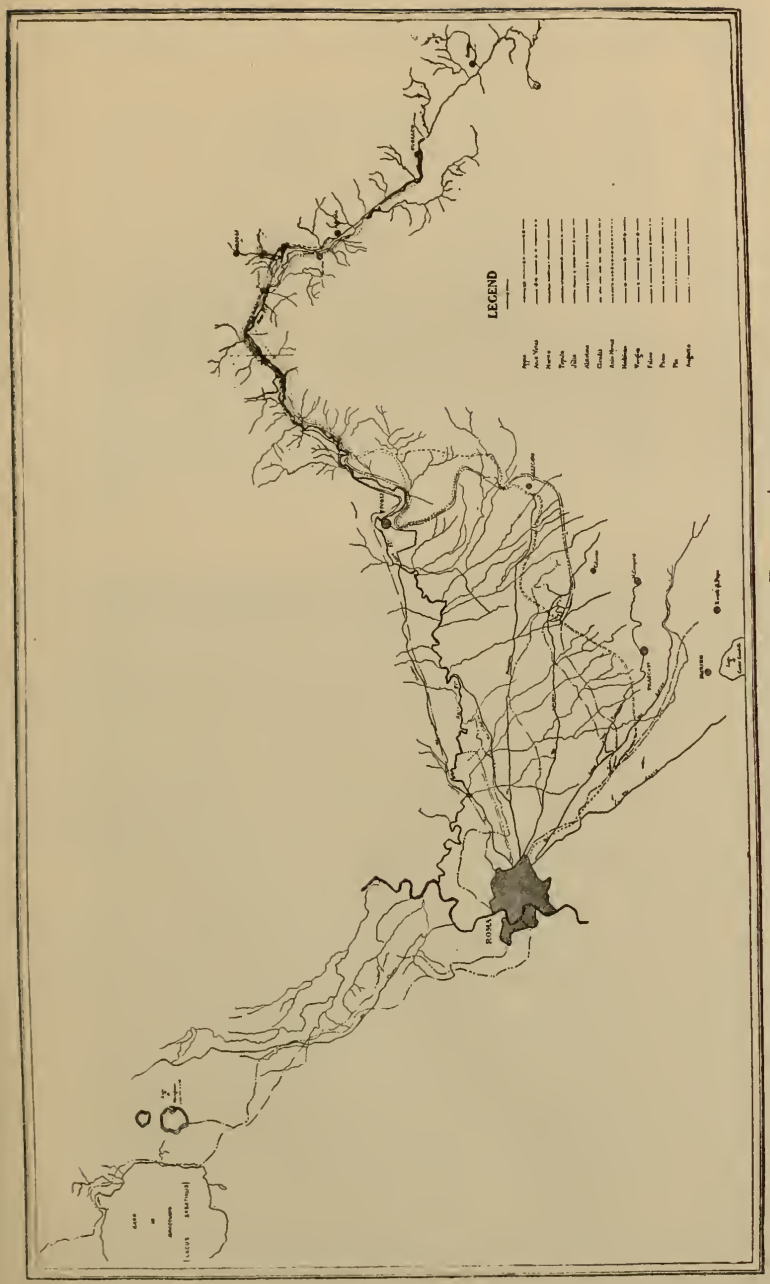
MARCIAN AQUEDUCT

For the first 441 years after the foundation of Rome the citizens obtained their water supply from the River Tiber, flowing through the city, and from springs within or near Rome. The first aqueduct for Rome (Plate II) was built about 312 B. C. under the direction of the Censor Appius Claudius Crassus, known as Coecus (the blind) and C. Plautius, known as Venox (the searcher of springs). Appius, though blind, appears to have had an eye to business. He induced Plautius to resign as censor, under the impression that he (Appius) would do likewise. Appius, however, held on to his office and managed to give his name not only to the first aqueduct of Rome which was called the Aqua Appia (The Appian Water), but, also to the famous Appian road, leading from Rome to Capua.

The Aqua Appia was about 10 miles long and was constructed underground with the exception of an arcade, 60 paces long, at the city's wall. Springs that may still be seen at the bottom of some stone quarries near the Anio River were its source. At a later period the Emperor Augustus brought some other springs into this aqueduct by means of a branch conduit, which joined the main aqueduct within the limits of the city. The junction of the two conduits was known as "the twins."

For about forty years the Appian Aqueduct supplied Rome with water and then it became necessary to secure an additional source of supply. The new conduit, built 272 to 269 B. C., tapped the Anio River about 20 miles east of Rome, but, owing to its circuitous location, the aqueduct, which was called the Aqua Anio Vetus (old Anio water) had a length of about 40 miles. With the exception of a length of a fifth of a mile, this aqueduct was also constructed below ground. The work was built under the direction of the Censors Manius Curius Dentatus and Fulvius Flaccus, the expense being paid out of the spoils of the Pyrrhic War.

About one hundred and twenty-five years later (144 to 140 B.C.) Rome had to build a third aqueduct, partly on account of the increase in consumption and partly on account of the loss of water due to leakage and unlawful diversion. The Senate commissioned the Praetor Q. Marcius Rex to repair the old conduits and to build a new aqueduct. Springs in the mountains near Subiaco, northeast of Rome, which were famous for their coolness and salubrity, were selected as the source of supply. The aqueduct had a length of about 57 miles, 50 miles of which were built below ground, and was named in honor of its constructor, Aqua Marcia. Pliny says of this supply: "Of all waters in the world that which we call the Marcia, in Rome,



Map Showing Location of Roman Aqueducts

carries the greatest name by the general voice of its citizens, in regard both to its coolness and salubrity, and we may esteem this water one of the greatest gifts the gods have bestowed on our city."

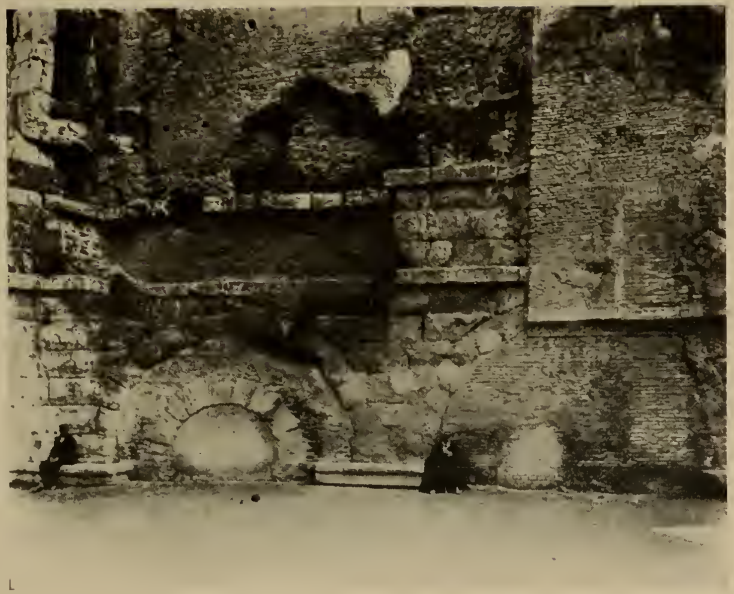
Fifteen years later (125 B.C.) the water supply of Rome was again increased by bringing water from springs in the volcanic rock southeast of Rome to the city. Owing to the tepid temperature of this water it was called the "Aqua Tepula" (tepid water). The conduit was about 12 miles long. Near Rome it was built on top of the Aqua Marcia, both conduits being thus carried by the same arcade (Plates I and III). The work was built under the direction of the Censors C. Servilius Caepio and L. Casius Longinus.

For ninety-two years Rome appears to have had enough water and then a fifth aqueduct was built (33 B.C.) by the Aedile M. Vipsannius Agrippa, to obtain an additional supply from springs near the source of the Aqua Tepula. The new aqueduct, which was named the Aqua Julia, in honor of the Emperor Julius Caesar Augustus, was 14 miles long and was built for part of its length on top of the Aqua Tepula, so that the Marcian arcade carried near Rome three aqueducts (Plate III), one above the other, viz., the Marcia, Tepula, and Julia (Plates I and III).

Fourteen years later (19 B.C.) the Aedile Agrippa, mentioned above, brought to Rome an additional supply of water from springs near the Anio River, northeast from Rome. According to tradition these springs were pointed out by a young girl (virgo) to the soldiers of Agrippa, who were looking for water, and hence the new supply was called the Aqua Virgo (virgin water). This aqueduct was about thirteen miles long and was built below the ground with the exception of a stretch about a mile long.

The sources of all of the aqueducts, thus far described, were to the east of Rome. About 10 B.C. the Emperor Julius Caesar Augustus had water brought to Rome from Lake Alsietinus, about 14 miles northwest of the city, through a conduit, twenty miles long and built almost entirely below the ground. The water obtained was not of good quality, and the aqueduct was constructed at a very low level. Its principal object was probably to supply the Naumachia (an artificial oval lake, 1742 feet long by 1161 feet wide on which exhibitions of sham naval battles were held).

Owing to the increase in population and luxury, two more aqueducts were built in 38 to 52 A.D. They were begun by the Emperor Caligula and were completed by the Emperor Claudius, after whom one of these conduits was named. This conduit, which was about 43



Marcian Aqueduct at the Aurelian Wall

miles long, brought water from two famous springs (Caeruleus and Curtius) to Rome. It was named the Aqua Claudia (Plate IV).

The second of these conduits, known as the Aqua Anio Novus (the new Anio water), tapped the Anio River about 42 miles from Rome. It had the largest delivery of all of the aqueducts of Rome, but the quality of the water was often bad, owing to the large amount of sediment the Anio carried after rains. At a later period a settling basin was built at the inlet of this aqueduct, but the water remained, nevertheless, muddy during heavy rains. The conduit was 54 miles long. In crossing the Campagna (a plain about 7–9 miles wide east of Rome) the Aqua Anio Novus was built on top of the Claudia Aqueduct (Plate IV).

At the Aurelian wall the Claudia, carrying the Anio Novus, was supported by the masonry of the city's gate, called now the Porta Maggiore (greater gate) Plate V, Figure 2. Here we still can read the following inscription, made when the aqueducts were built: "Tiberius Claudius, the son of Drusus Caesar Augustus Germanicus, Supreme Pontiff, in the twelfth year of his tribunate and fifth consulship, proclaimed imperator (on the field of battle) twenty-seven times, the father of his country, caused to be brought into the city, at his own expense, the Claudian water from the springs called Caerulius and Curtius, from 45 miles away, also Anio Novus, from 62 miles away."

It detracts somewhat from this grandiloquent statement to read right below it that nineteen years later (including nine years of disuse) Vespasian restored these two aqueducts to usefulness. A third inscription informs us that Titus, Vespasian's son, had to make extensive repairs to the aqueduct about ten years later.

One of the principal roads entered Rome at the Porta Maggiore. On one side of this road was the arcade of the Marcia, carrying also the Tepula and Julia, while on the other side of the road was the arcade of the Claudia, supporting, also, the Anio Novus. These two arcades were only about 100 yards apart, the Marcian being about 30 feet high, while the Claudian had an elevation of about 50 feet. This must have impressed a stranger approaching Rome for the first time. A few miles outside of Rome at the Porta Furba these two arcades crossed each other, a tower being built at the point of intersection.

The nine aqueducts which we have described supplied Rome in the year 97 A.D. when the Emperor Nerva Augustus appointed Sextus Julius Frontinus "Curator Aquarum" (caretaker of waters) or as we would say "Commissioner of Water Supply." Frontinus, who

was at that time in his sixty-second year, had a very honorable record. He was born of a patrician family, had been praetor, three times consul, had distinguished himself as a soldier, and had been governor of Britain. He had written a treatise on *Surveying* and another on *The Art of War*. On assuming charge of the water supply of Rome, Frontinus gathered all the available historical data about the nine aqueducts, measured and gauged these conduits to the best of his knowledge, and wrote a description of the works, which has been translated into English, French and German, and is read with as much interest now as of old. Frontinus appears to have been a very conscientious official. He did his utmost to abolish abuses and to introduce reforms. In gauging the aqueducts he only measured the width and depth of the stream, and, unfortunately, paid no attention to the velocity of the current.

Frontinus divided the "wetted area" of each aqueduct by the area of a small pipe, called a "Quinaria," having an area of 0.632 square inches, and he expressed the flow in an aqueduct as being equal to so many "quinariae." Of course, a modern hydraulic engineer would not agree to this method, as there is much more friction relatively in a small pipe than in a large one. From the data given by Frontinus, the following table has been compiled:

Roman aqueducts described by Frontinus. (97 A.D.)

NAME	DATE	LENGTH IN MILES			HEIGHT OF WATER ABOVE QUAY OF THE TIBER, IN FEET	NUMBER OF RESERVOIRS	TOTAL SUPPLY IN QUINARIAE
		Below ground	Above ground	Total			
	B. C.						
Appia	312	10.23	0.06	10.29	27.5	20	704
Anio Vetus	272-269	39.33	0.20	39.53	82.6	35	1610
Marcia	144-140	49.87	6.86	56.73	123.0	51	1935
Tepula	125	5.51	6.44	11.95	125.4	14	445
Julia	33	7.75	6.44	14.19	130.3	17	803
Virgo	19	11.83	1.14	12.97	34.2	18	2504
	A. D.						
Alsietina	10?	19.96	0.33	20.29			392
Claudia	38-52	33.31	9.35	42.66	155.6		
Anio Novus	38-52	45.32	8.64	53.96	155.9	92	5625
TOTALS		223.11	39.46	262.57		247	14018

The cross sections of these aqueducts are given in Plate VI. As no two are alike, the conduits could be easily identified.

Some additional aqueducts and branch conduits were built for Rome after Frontinus' time. The Aqua Trajana was built by the

Claudian Aqueduct

In the Campagna

At the Porta Maggiore

Claudian Aqueduct

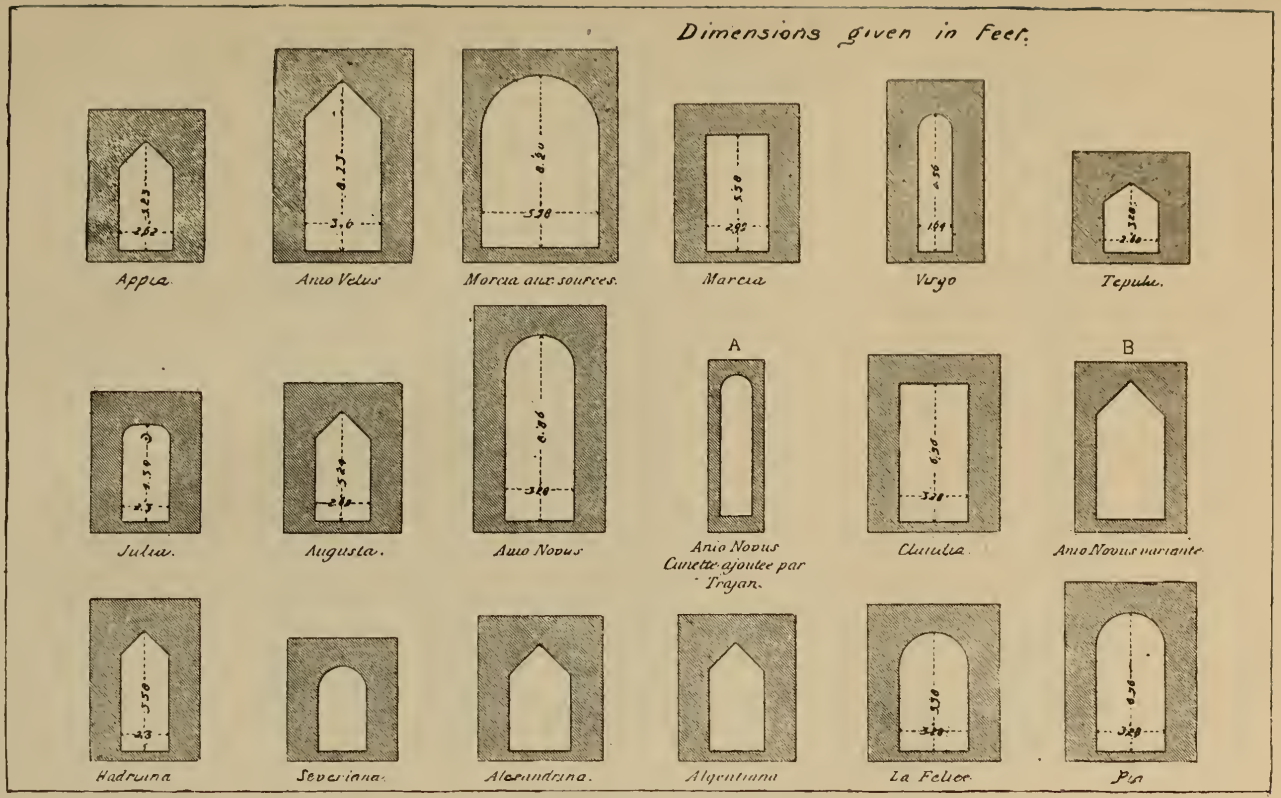
Emperor Trajan in 109 A.D. to bring water to Rome from springs north of Lake Sabatinus, lying northwest of the city (Plate II). At a later date this aqueduct was connected with the lake.

The Aqua Hadriana was built by the Emperor Hadrian in 120 A.D. to supply his villa near Cento Celle, about 5 miles from Rome. At a later period this conduit was continued by Rome, probably by the Emperor Alexander Severus. For this reason this conduit is sometimes called the Aqua Alexandrina.

The Aqua Aurelia was built in 185 A.D. by Marcus Aurelius to convey water from springs southeast of Rome to his Villa de Quintilii. It was an important aqueduct and was built of brick masonry. Septimius Severus extended the Aurelia in 196 A.D. into Rome, and the conduit took then the name of Aqua Severianna. Besides the twelve aqueducts we have described, there were a number of branch conduits. Having described the history of the aqueducts of Rome, we shall now mention some of the details of their construction.

The location of the aqueducts of Frontinus' time and of some modern aqueducts to be described later, is shown in Plate II. The lines were made much longer than the location that would be made by a modern engineer, as the Romans had no good materials for siphon pipes, and avoided arcades on account of the expense. About the only material which was available for making pipes was lead, but this was expensive. The sheets of lead were bent to the piriform shape shown in Plate VII Figure 2, and the joint was made by pouring molten soft lead. The Romans had no solder. Sometimes the lead pipes were encased in masonry, when used for crossing deep valleys.

Owing to the very primitive instruments used for leveling (Plate VII, Fig. 1), the Romans adopted much steeper grades than are now used for aqueducts. The grades of the nine aqueducts described by Frontinus have not yet been accurately measured. Those of the Roman aqueducts in other parts of Europe vary from 1:3000 to 1:600. In some of these conduits the grades are quite regular, while in others the opposite is the case. The Roman level shown in Plate VII is drawn from a description given by the architect and engineer Vitruvius, who lived about the beginning of the Christian era. It consisted of a straight edge, about 20 feet long, having a small water-channel, about 5 feet long in the center. By filling this channel partly with water, it could be roughly ascertained whether the instrument was level, but the main reliance in leveling was placed on two plumb-bob lines, one at each end of the straight edge, which had to agree with scratch marks on the level when it was horizontal. The levels were run by sighting over the instrument after it had been made horizontal.



SECTIONS OF ROMAN AQUEDUCTS

The aqueducts were constructed, as a rule, in tunnel, so as to hide them from view. In crossing the plain to the east of Rome, known as the Campagna, the aqueducts were carried on arcades, the longest of which had a length of about six to seven miles.

The shafts for the tunnels were usually about 240 feet apart, a distance corresponding to an old Roman measure. When rock was encountered, it was removed, if sufficiently soft, by chiseling and wedging. For hard rock the "fire-setting" system was used. This consisted in heating the rock by means of fires and then cooling it suddenly with water. Cracks were thus formed in the rock and enabled the miners to remove it by wedging. The "fire-setting" system has been used until recent times in parts of Germany, Russia and in Japan.

The early aqueducts were built entirely of dry cut stone masonry, mortar being only used for lining the water channel. At a later period, the aqueducts were built of rubble masonry and brickwork. The Roman bricks were triangular in shape and about $1\frac{1}{2}$ inches thick.

The bottom of the water channel was left rough, probably in order to reduce the velocity of the water, and to keep back sediment. Numerous angles were introduced in the lines of the aqueducts, usually at intervals of about half a mile. Perhaps this was also done to retard the velocity of the water. At each of these angles a small reservoir was built, and sometimes also a settling basin. These reservoirs served for distributing water along the line of the conduit, where required. Ventilators were built at frequent intervals along the aqueducts and were generally provided with steps for entering the conduits. Water was drawn at these places by means of buckets.

The aqueducts terminated in Rome in large reservoirs, from which the water was conveyed in leaden pipes to private reservoirs, which were usually built at the expense of several water takers, who clubbed together for this purpose. From these reservoirs the water was conducted in lead pipes to the small domestic cisterns, generally built of lead, which were placed in the courtyards of the houses. The quantity of water flowing in or out of each reservoir or cistern was determined by the size of the pipe or pipes through which the water passed. The quantity of water that could be drawn to each domestic cistern was regulated by a short, bent tube of bronze, called a "calyx," which was inserted in the side wall of the private reservoirs and formed the inlet to the service pipe.

The total consumption of water in Rome in the beginning of the Christian era has been greatly exaggerated. M. Rondelet, a French engineer, by adopting erroneous assumptions as regards the discharge

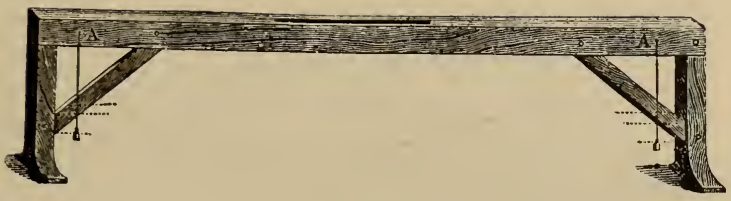


FIG. NO. 1.—ROMAN LEVEL

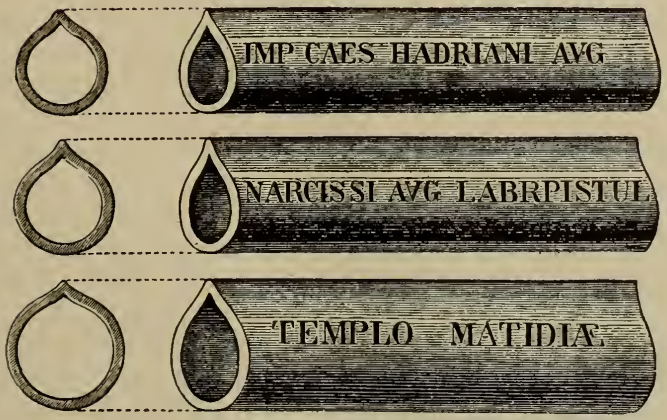


FIG. 2.—ROMAN PIPES.

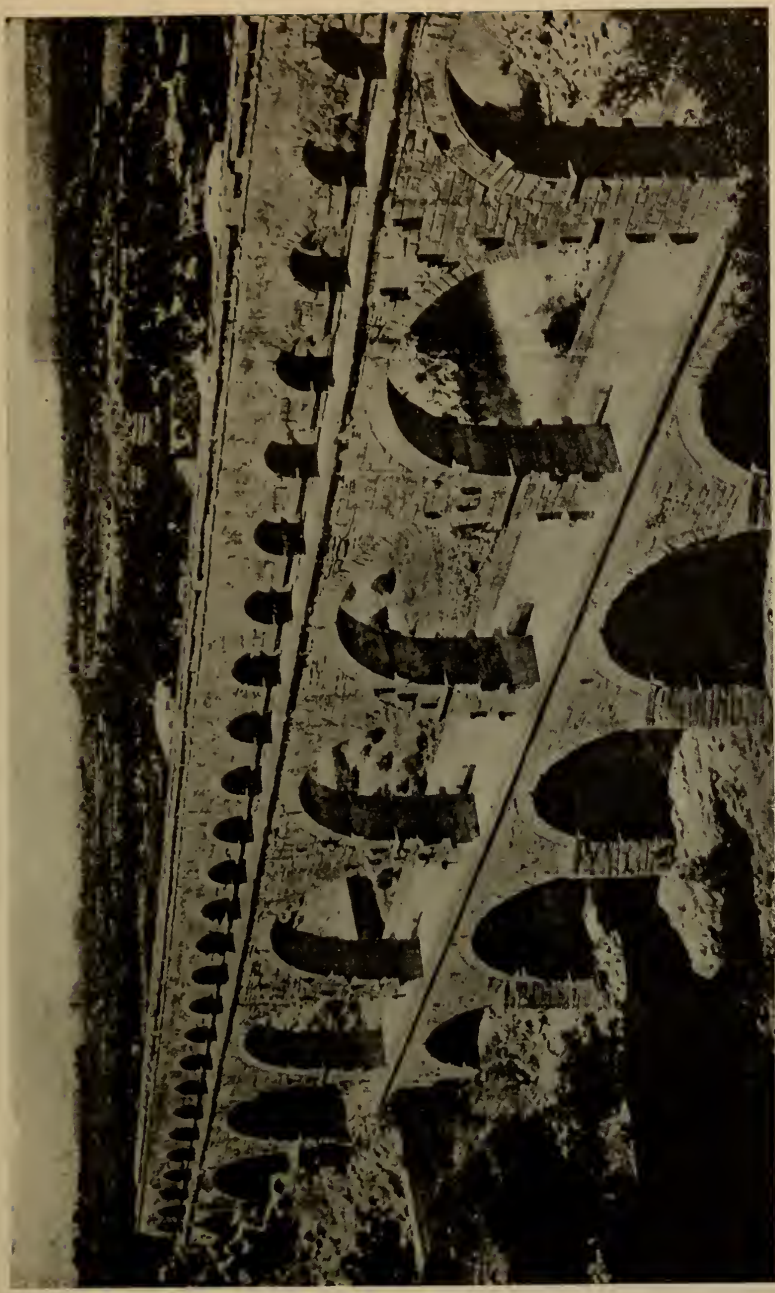
of a quinaria, and by multiplying this by the number of quinaria mentioned by Frontinus, estimated the daily discharge of the nine aqueducts at about 393,000,000 United States gallons. Mr. Clemens Herschel has pointed out in his book on *Frontinus and the Water Supply of Rome*, that the discharge of the nine aqueducts probably never exceeded about 84,000,000 United States gallons per day.

Frontinus tells us in detail how the water brought by the aqueducts was distributed in each of the fourteen wards into which Augustus divided Rome. The water registers kept accounts of how much water was used for public purposes and how much was required for private consumption, but, partly on account of the faulty methods of gauging and partly on account of abuses, which had gradually got into the registers' office, Frontinus found it impossible to make the total supply of the city, based upon his gaugings, agree with the quantity for which the registers could account. Part of the difficulty was caused by rich and influential persons diverting some of the water for their own use. There was, also, much leakage from the conduits. According to a law in existence in the time of Frontinus, the men in charge of the aqueducts had the right to sell all water that leaked. Consequently when a leak occurred, the men in charge of the conduit were more apt to encourage than to stop the leak. Extensive repairs were made on the aqueducts from time to time and these were sometimes recorded on tablets.

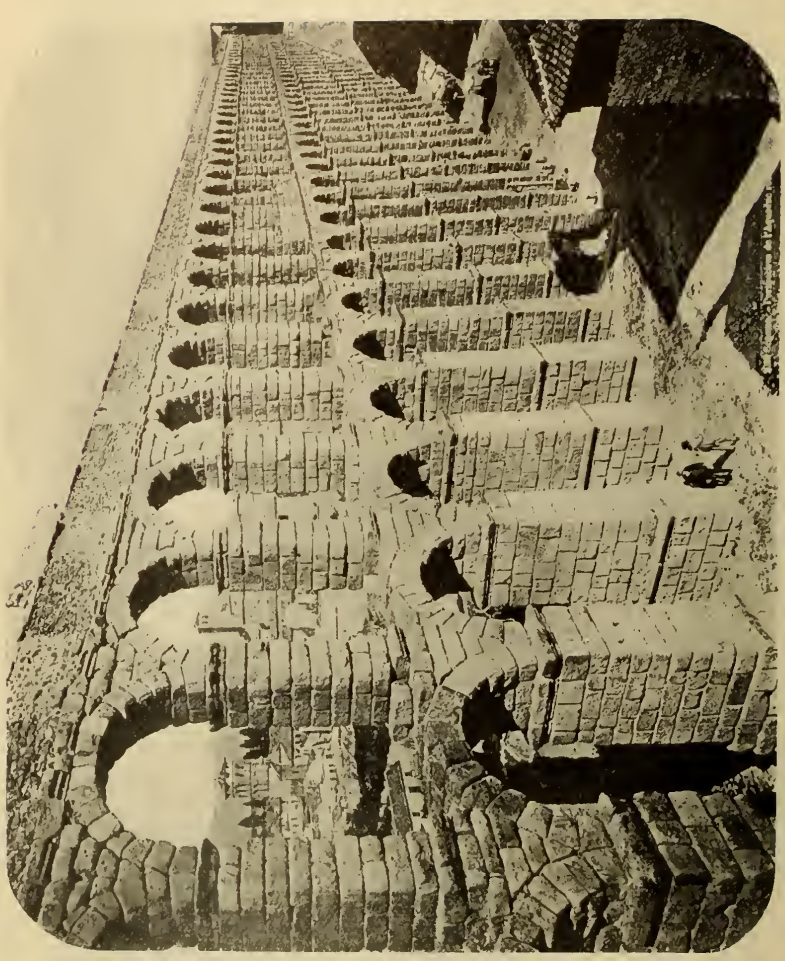
Having described briefly the aqueducts that supplied the imperial city of Rome we will mention some similar works built by the Romans in other countries.

The most famous of the series of such aqueducts is the "Pont du Gard" (Plate VIII) which formed part of the aqueduct of Nismes. The structure was built, in the first century of the Christian era, of dry masonry, with the exception of the lining of the water-channel. The arcade, which is 160 feet high, is composed of three tiers of semicircular arches. The lowest tier contains six arches, the one across the river Gard having a span of 80 feet 5 inches. On one side of this arch there are three arches of 63 feet span, and on the other side there are two arches of 51 feet span. The arches of the second tier have spans of 51 feet and those of the third tier have spans of 15 feet 9 inches. The arcade is 883 feet long on top and is 21 feet wide at the bottom, and 10 feet wide at the top.

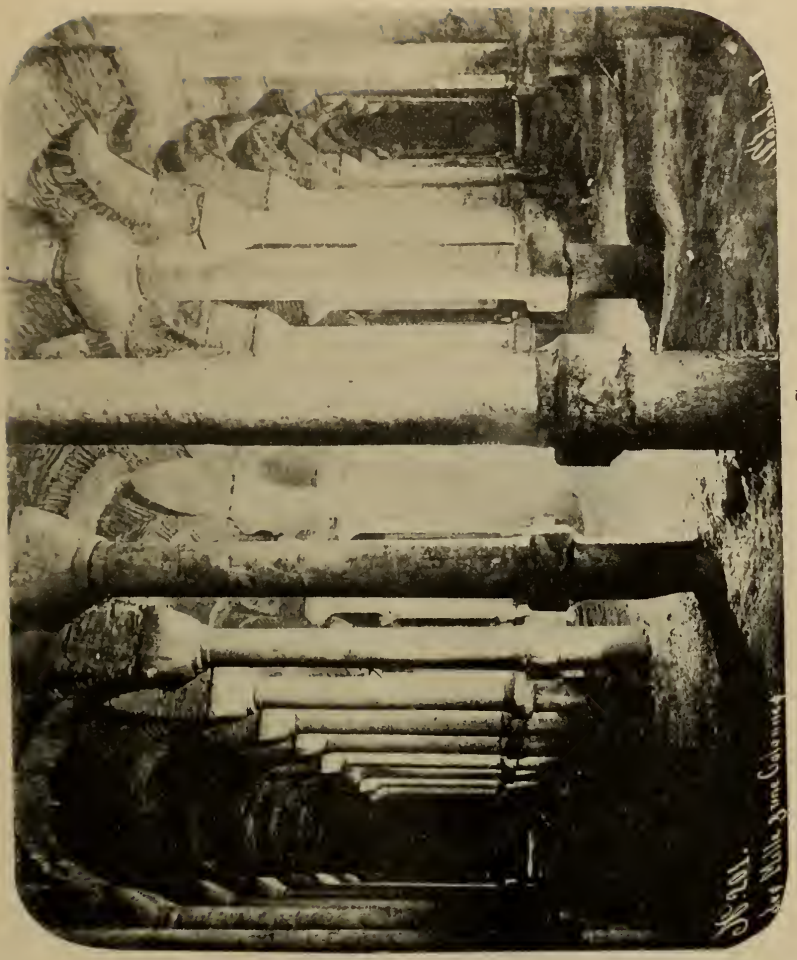
Another famous arcade, built about the same time as the Pont du Gard, forms part of the aqueduct of Segovia, Spain (Plate IX). It is still in service. The arcade, which is built of dry masonry, is 2400 feet long and has a maximum height of 102 feet.



Pont du Gard



Aqueduct of Segovia



Cistern of 1001 Columns in Constantinople

The Roman Emperors built very important aqueducts for the city of Constantinople and constructed a large number of subterranean reservoirs for storing water to supply the city in case of being besieged. One of the most famous of these reservoirs, known as the "cistern of a thousand and one columns" is shown in Plate IX A.

Most of the aqueducts built by the Romans were more or less destroyed in the time of the migration of nations. By the middle of the sixth century all of the aqueducts that supplied Rome had either been cut off by the barbarians, or had lost their supplies by neglect. The city had again to draw water from the River Tiber, and from springs within its walls.

In 1559 Pope Pius IV restored the Aqua Virgo and this conduit, known now as the Aqua Vergine, has continued since that time to supply part of Rome with water. In 1585 to 1587 Pope Sixtus V (Felice Peretti) built an aqueduct that brings water to Rome from springs, southeast of Rome, that formerly supplied the Hadriana. For part of the distance portions of the old aqueduct were used. This conduit was named after the Pope the Aqua Felice.

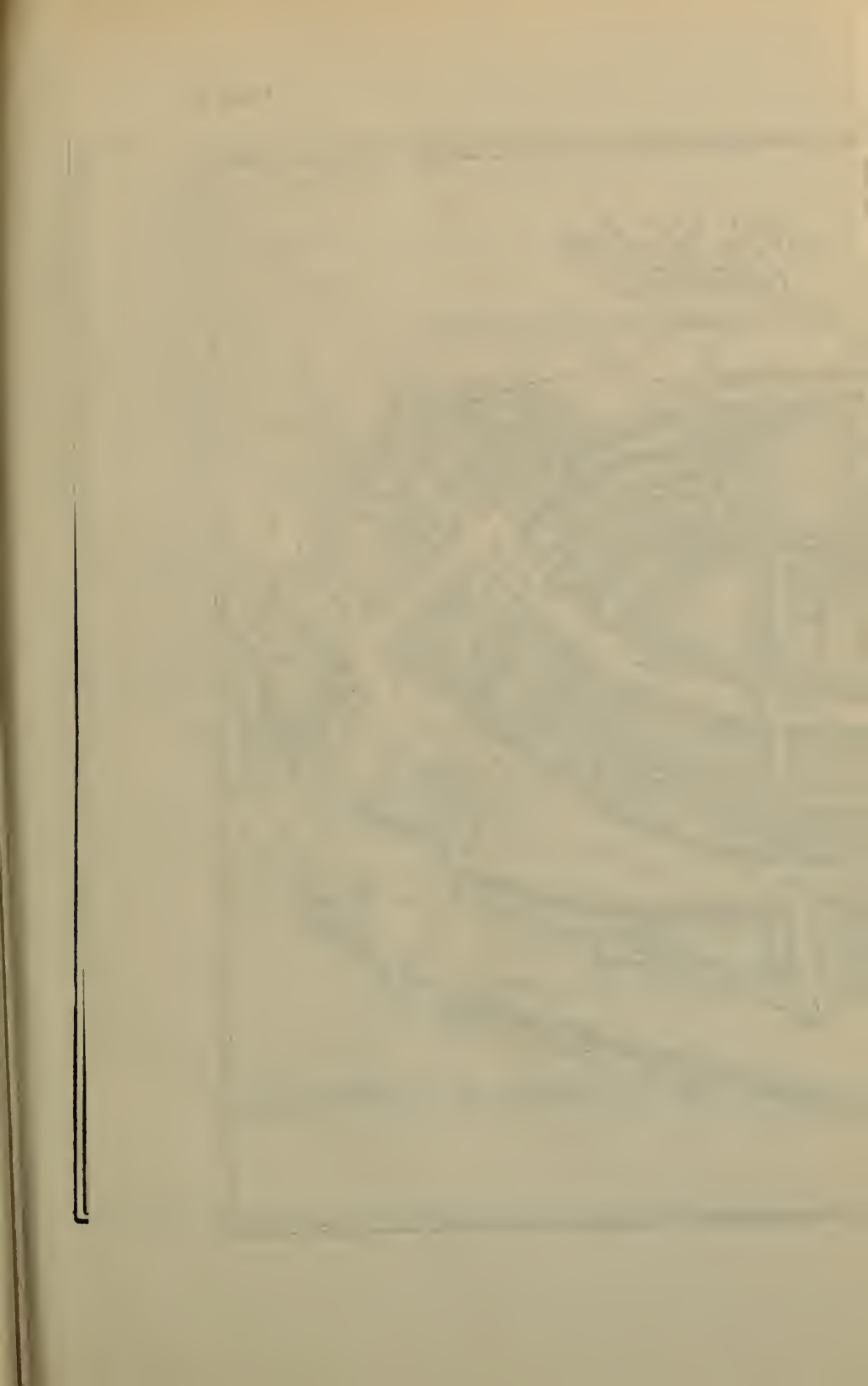
Pope Paul V restored the Trajana in 1618 and connected it directly with Lake Sabatinus (Plate II). The water was distributed through the city by branch conduits and supplies many of the public fountains. The conduit was named in honor of the Pope "Aqua Paola."

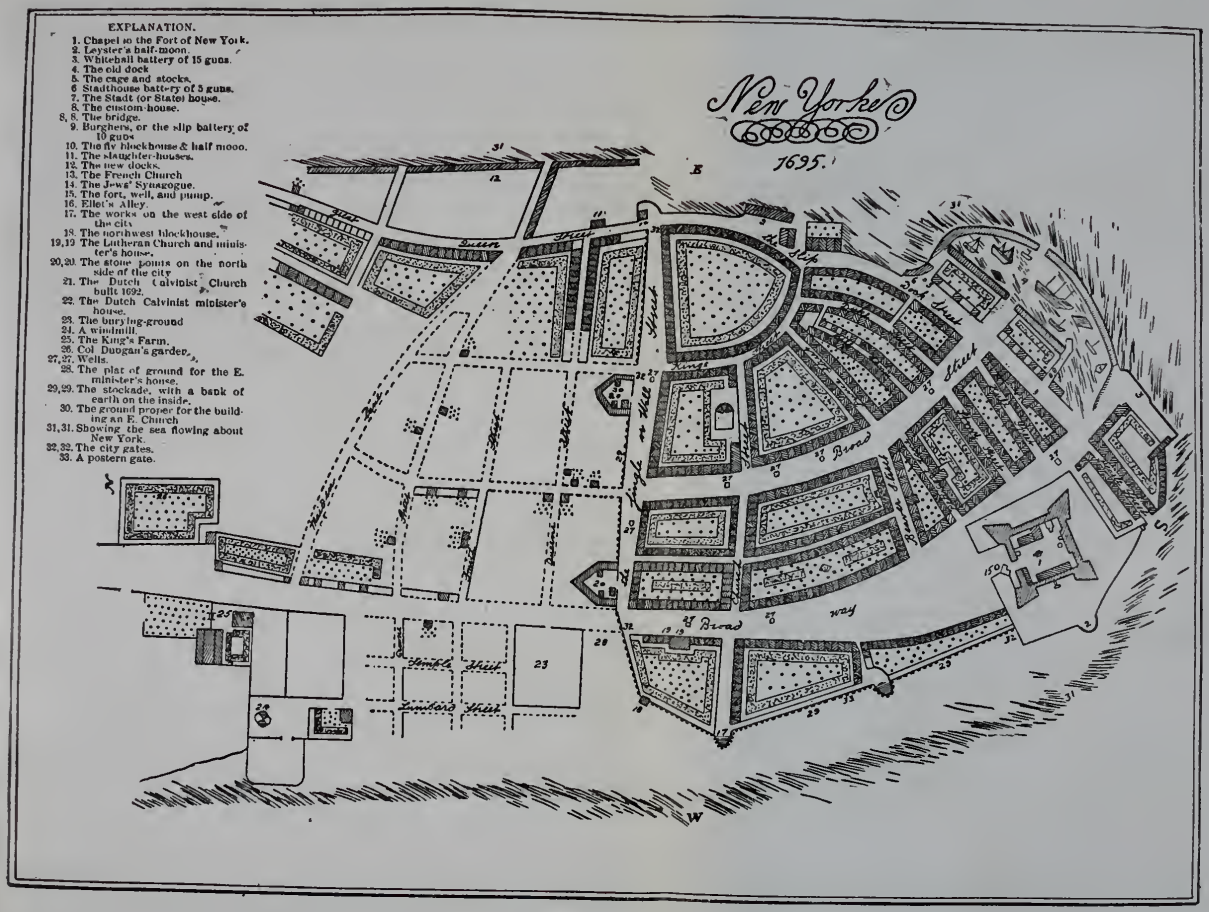
In 1860 to 1870 a private company built an aqueduct to bring water to Rome from the famous springs that supplied the Marcia. This conduit was named after Pope Pius IX, who took a lively interest in the work, the "Aqua Pia." By using siphons of cast iron pipes the new aqueduct was built on a much shorter location than that of the old conduit. Whereas the latter had a length of fifty-seven miles, the former has only a length of 32.6 miles. The four aqueducts mentioned are all that supply modern Rome. Their length, capacities, etc., are as follows:

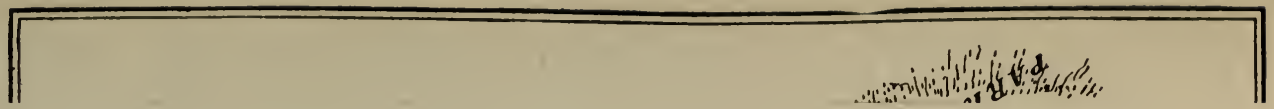
Water Supply of Modern Rome

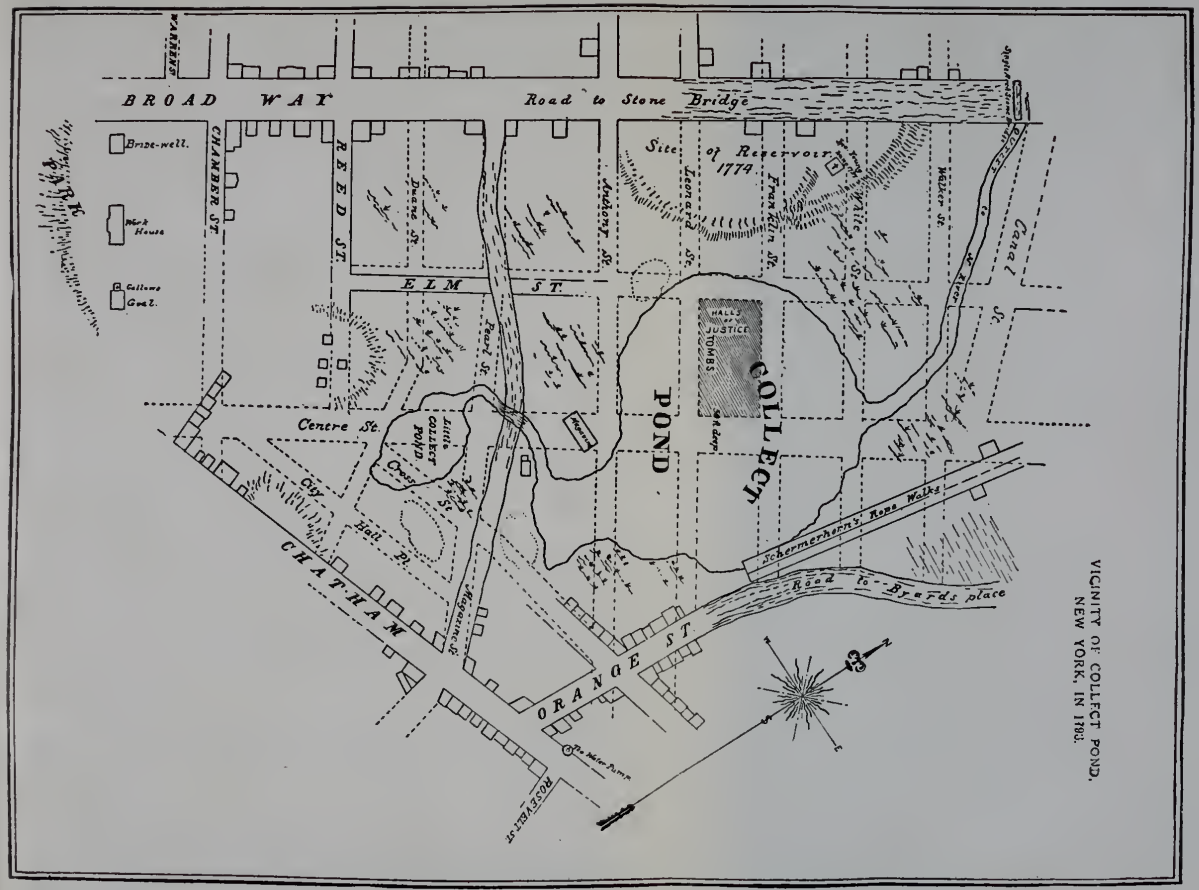
NAME	DATE	AUTHOR	LENGTH IN METERS	VOLUME IN 24 HOURS, IN CUBIC METERS
Aqua Vergine	1559	Pius IV	20,546	155,271
Aqua Felice	1587	Sixtus V	32,593	21,633
Aqua Paola	1611	Paul V	51,852	80,870
Aqua Marcia-Pia	1870	Societa dell'Aqua Marcia-Pia	53,649	121,306

The total supply, according to the above table, is 379,080 cubic meters or 100,130,000 gallons per twenty-four hours.




EXPLANATION.
1. Chapel or the Fort of New York.
2. Leyster's half-moon.
3. Whitehall battery of 15 guns.
4. The old dock
5. The cage and stocks.
6. Stadthouse battery of 5 guns.
7. The Stadt (or State) house.
8. The custom-house.
8, 8. The bridge.
9. Burghers, or the slip battery of 10 guns
10. The fly blockhouse & half moon.
11. The slaughter-houses.
12. The new docks.
13. The French Church
14. The Jews' Synagogue.
15. The fort, well, and pump.
16. Ellet's Alley.
17. The works on the west side of the city
18. The northwest blockhouse.
19,19 The Lutheran Church and minister's house.
20,20. The stone bouns on the north side of the city
21. The Dutch Calvinist Church built 1692.
22. The Dutch Calvinist minister's house.
23. The burying-ground
24. A windmill.
25. The King's Farm.
26. Col Dungan's garden.
27,27. Wells.
28. The plat of ground for the E. minister's house.
29,29. The stockade, with a bank of earth on the inside.
30. The ground proper for the building an E. Church
31,31. Showing the sea flowing about New York.
32,32. The city gates.
33. A postern gate.
New Yorke
1695.
Duane
Hudson
Dock
Broad
Wall
Smith Hill
Lumford Hill
Bowling Green
Virginia
E
W





VICINITY OF COLLECT POND, NEW YORK, IN 1793.

In the preceding pages we have described the water works of ancient times and have mentioned briefly how Modern Rome is supplied with water. As it is impossible to describe within the limits of this paper the water works of the principal modern cities, we shall confine our remarks to the greatest water works of modern times, viz., those of the City of New York. It may be of interest to trace the growth of these works from the beginning to the present time.

Prior to 1774 the inhabitants of New York, then called New Amsterdam, obtained the water required for domestic purposes from the public wells, which were generally sunk in the center of the streets, so as to make them readily accessible for extinguishing fires. The first of these wells was sunk in 1658 in front of the old fort at Bowling Green. The location of this well and of some others sunk soon afterwards is shown in Plate X.

In 1774 the first public water works were constructed for New York, according to plans prepared by Christopher Colles, an English civil engineer. Water was pumped by steam engines from the old "Collect Pond" (Plate XI), which occupied the space where now stand the Tombs and the surrounding blocks, to a reservoir constructed on the east side of Broadway between Pearl and Walker Streets. The water was distributed through hollow logs, laid in the principal streets of the city. Owing to the insufficient supply and the confusion caused by the revolution, these works were soon abandoned.

In 1799 the Manhattan Company obtained a charter for supplying the city of New York with pure and wholesome water. This company sank some wells near the northwest corner of Reade and Center Streets from which water was pumped into a reservoir built on the north side of Chambers Street, between Broadway and Center Street, whence the water was distributed through hollow logs. The supply furnished by the Manhattan Company was insufficient in quantity and bad in quality.

In 1834 the legislature of the state authorized the city of New York to obtain a supply of "pure and wholesome water" from the Croton River. The works necessary for securing this supply were constructed in 1837 to 1842.

A "fountain reservoir" was formed by building a dam, 50 feet high, across the Croton River, about 9 miles above its mouth. From this reservoir the water was conveyed to the City in a masonry conduit, 8 feet $5\frac{1}{2}$ inches high and 7 feet 5 inches wide (Plate XII), and having a length of 40 miles. For the greater part of its length the aqueduct followed the east bank of the Hudson River, being generally

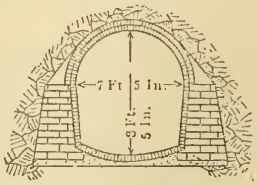
Aqueducts and Pipe Lines which Deliver 80 per cent of the Water Supply of Greater New York

Capacity-25 Mil. Gal per Day

2-48 Inch Cast Iron Pipes Delivering from Ridgewood Watershed
1-48 " " " Pipe " Bronx & Byram "

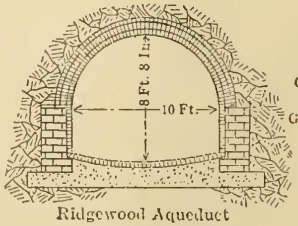
Capacity-50 Mil Gal per Day

72 Inch Steel Pipe Delivering from Ridgewood Watershed.



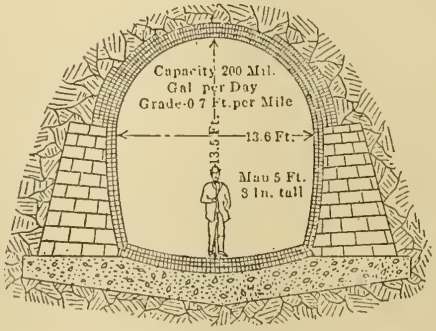
Capacity-90 Mil. Gal per Day
Grade-1 4 Ft. per Mile

Old Croton Aqueduct



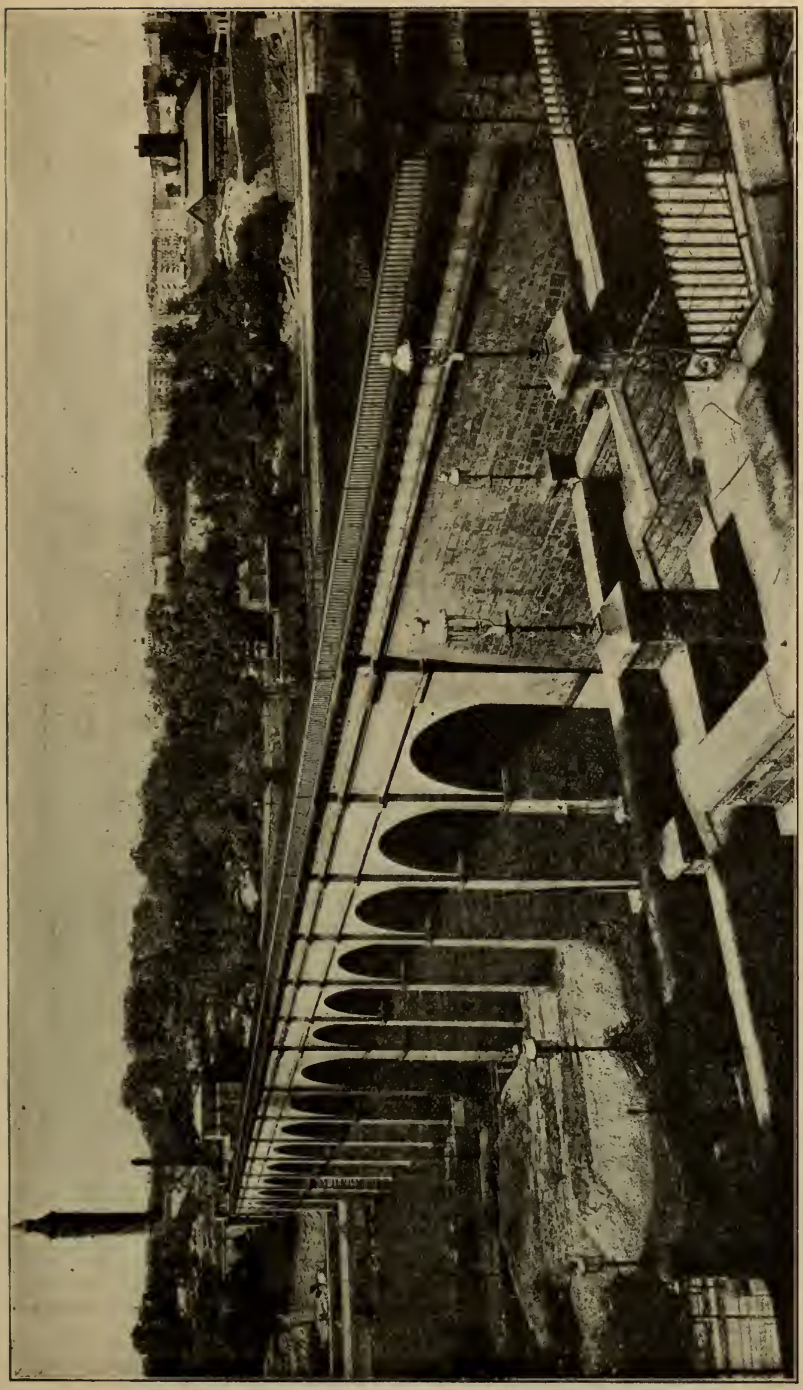
Capacity 75 Mil. Gal per Day
Grade-0.5 Ft per Mil

Ridgewood Aqueduct



New Croton Aqueduct

The Engineering Magazine



High Bridge

built as "cut and cover work." Small mountain spurs were pierced by tunnels, and valleys were usually crossed by dry stone embankments on top of which the conduit was built. The Harlem River was crossed by a fine aqueduct bridge, having fifteen semi-circular arches, viz: eight of 80 feet span and seven having spans of 50 feet. This bridge, known as "High Bridge" (Plate XIII) is about 120 feet high above high tide. The water was received in a reservoir of 180,000,000 gallons capacity, built on land forming now part of Central Park, and was then conveyed through three lines of 36 inch mains to a small reservoir on Murray Hill, at 42nd Street and Fifth Avenue, where it was let into the distributing mains.

The works described above were first put into service on July 4, 1842. For nearly fifty years they supplied the city, although they were severely strained to keep up with the increasing consumption. According to the original plans, the Old Croton Aqueduct, as the conduit described above is now called, was only to deliver about 36,000,000 gallons per day. To keep up with the consumption this conduit was forced by 1880 to deliver about 95,000,000 gallons daily.

In 1880 to 1884 a small additional supply of 23,000,000 gallons per day was obtained from the Bronx and Byram Rivers.

In 1884 to 1891 a second aqueduct, having a capacity of about 300,000,000 gallons per day, was built from the Croton Valley to the city of New York. This conduit (Plate XII), known as the New Croton Aqueduct, is 13.53 feet high and 13.6 feet wide. From the Croton Valley to a terminal gate-house at 135th Street and Convent Avenue in the city, the new aqueduct was constructed entirely in tunnel, with the exception of a few short sections, aggregating 1.12 mile in length, where the conduit was built in open cut. The Harlem River was crossed by a siphon tunnel, about 1300 feet long, excavated about 300 feet below tide. At the 135th Street gate house the water was connected with the distributing pipe system by eight lines of mains, each four feet in diameter (Plate XIV). The new aqueduct, which has a length of 33 miles, including the pipe lines, was put into service in 1890. Its construction cost about $20,000,000, not including land.

In order to obtain as much water as possible from the Croton River, a number of storage reservoirs were built from time to time on the main river or its affluents, in order to retain the excess of water during periods of flood to feed the river during times of droughts. The rerservoirs that have been constructed in the Croton Watershed are mentioned in the following table:

Terminal Gate House in Central Park

Pipe Line on Convent Avenue; 8 Lines of 48-Inch Mains

Storage Reservoirs in the Croton Watershed

	PUT IN SERVICE	STORAGE CAPACITY IN M. GALS.
Old Croton Lake[1]	1842	
Boyds Corners	1873	2,727
Middle Branch	1878	4,155
East Branch	1891	5,243
Bog Brook	1891	4,400
Titicus	1893	7,617
Carmel or West Branch	1895	10,668
Amawalk	1897	7,086
New Croton	1905	33,815
Cross River	1908	10,923
Croton Falls	1910	15,753
	Total	102,387

[1] Included in New Croton Reservoir now.

Besides the storage mentioned above, the city obtains an additional quantity of water by drawing down a number of lakes and ponds, which it either owns or controls. The quantity of water that can be drawn from these lakes and ponds is given in the following table:

Storage in lakes and ponds in the Croton watershed

	Storage capacity in millions of gallons
White Pond	200
Barrets Pond	170
Lake Gleneida	165
Kirk Lake	565
Lake Mahopac	575
Lake Gilead	380
	2055

From the two tables given above it is seen that the total quantity of available storage in the Croton Watershed amounts to 104,442,000,000 gallons.

The works which have been described are those of the former city of New York which forms, since 1908, the boroughs of Manhattan and the Bronx of the Greater New York. Each of the boroughs of Brooklyn, Queens and Richmond has its own water works. Brooklyn is supplied from streams on Long Island and from ground water. This supply is brought to Brooklyn by a masonry conduit, two lines of 48 inch cast iron pipe and a 72 inch steel pipe, known respectively as the Ridgewood Aqueduct and pipe lines (Plate XII). The boroughs of Queens and Richmond are supplied by pumping ground water from driven wells.

The three aqueducts supplying Manhattan and the Bronx can deliver about 400,000,000 gallons per day. In a case of a severe drought, the Croton, Bronx and Byram Rivers will not yield more on an average than about 310,000,000 gallons a day. As the two boroughs mentioned consume, at present, more than 300,000,000 gallons per day, it is evident that some new source of supply must soon be drawn on. This fact was realized in 1900.

In 1902 a commission of three expert engineers—Professor William H. Burr, Rudolph Hering and John R. Freeman—was appointed to investigate all possible sources from which New York could obtain an additional supply of water. This commission recommended that a daily supply of 250,000,000 gallons be obtained from the streams in Dutchess County, immediately north of the Croton water shed, and that an additional supply of 250,000,000 gallons be secured from streams in the Catskill mountains.

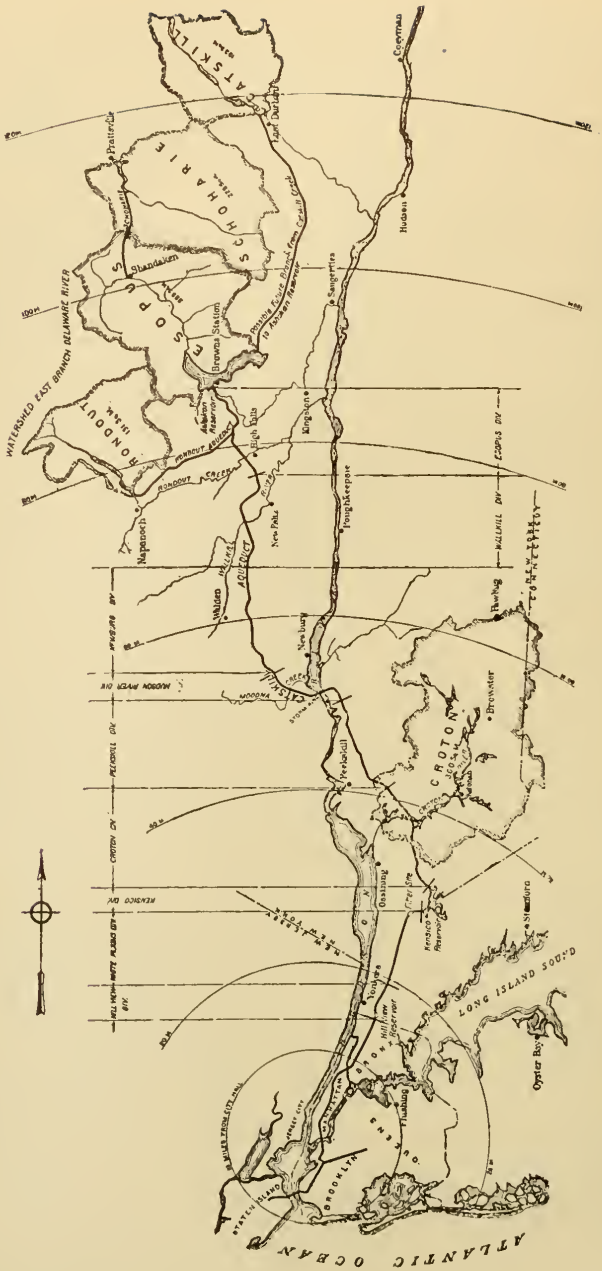
On June 3, 1905, the Legislature passed an Act authorizing the city of New York to construct works for obtaining an additional supply of water. As the Legislature had, at a preceding session, passed a bill preventing the city of New York from diverting any water from Dutchess County, the city had to go to the Catskill mountains to obtain its supply. In view of the present growth in population of the Greater New York, which is at about the rate of 125,000 per annum, it was decided to give the new works a capacity of 500,000,000 gallons per day. The works have been under construction since 1905, under the direction of a board of water supply, composed at present of the following three commissioners: Charles Strauss, Charles N. Chadwick and John F. Galvin. Mr. J. Waldo Smith is the chief engineer of the board.

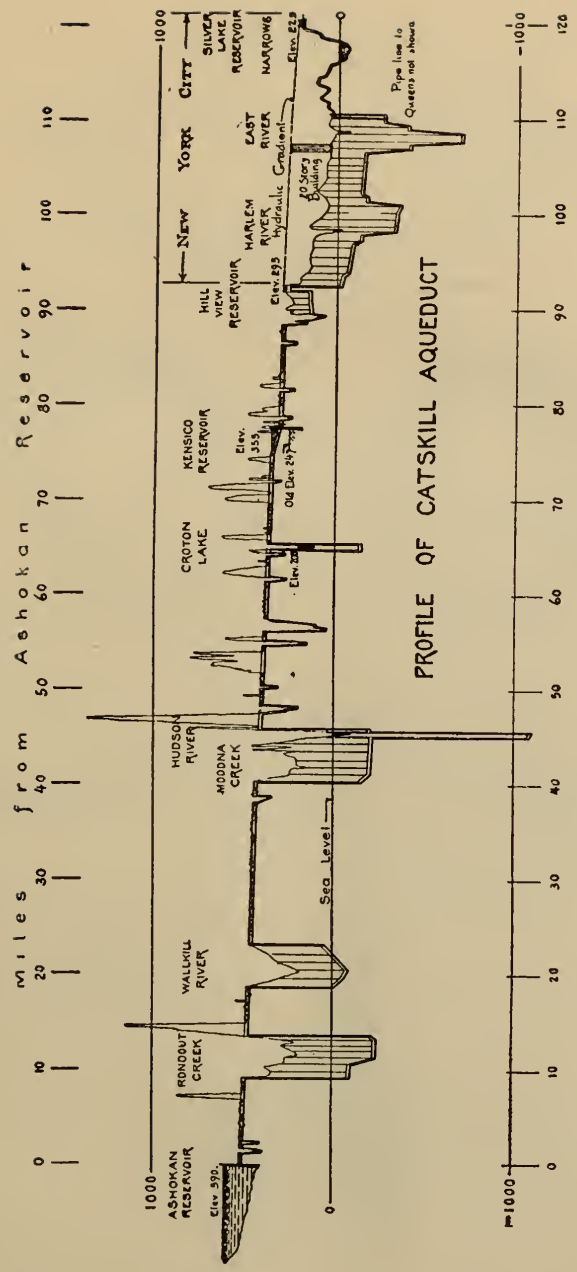
The work when completed will consist of an aqueduct (Plate XVII) 17 feet high by 17½ feet wide, capable of delivering daily 500,000,000 gallons. Valleys are to be crossed either by pressure tunnels or by siphons of steel pipe. The water is to be distributed to all of the five boroughs of Greater New York (Plate XV and XVI).

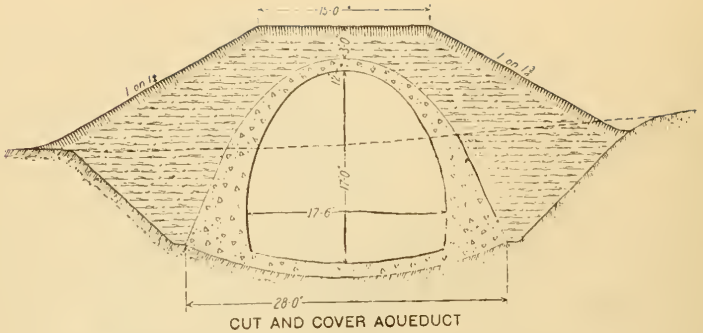
The Catskill Aqueduct, as the new conduit is called, will consist of:

	Miles
Cut and cover aqueduct	55
Grade tunnel aqueduct	14
Pressure tunnel aqueduct	17
Steel siphon pipes	6
Total	92

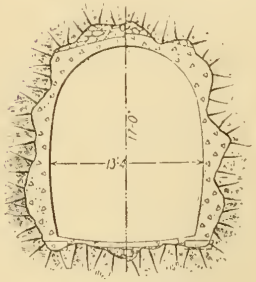
The cross section of the different parts of the aqueduct are shown on Plate XVII.


CATSKILL WATERSHEDS AND AQUEDUCT
CATSKILL
SCHOHARIE
ESOPUS
ROONDOUT
WATERSHED EAST BRANCH DELAWARE RIVER
Ashokan Reservoir
Browns Station
Shandaken
Phoenicia
Kingston
Saugerties
Hudson
Coxsackie
Catskill
Tannersville
Tongkkeepsie
Newburg
Rondout Creek
Rondout Reservoir
Napanoch
Wilden
Aqueduct
New Paltz
High Falls
Rhinebeck
Rhinecliff
Rondout
Esopus Creek
Roundout Creek
Roundout Reservoir
Walkill Div.
Esopus Div.
Wallkill Div.
Rondout Div.
Croton Div.
Hudson River Div.
Pelham Div.
Kensico Div.
Hill View Reservoir
Kensico Reservoir
Ossining
Croton Falls
Croton Lake
Croton Reservoir
Croton Aqueduct
Croton Dam
Croton
Brewster
Peekskill
Rawling
Yonkers
Van Cortlandt Park
Harlem River
Manhattan
Brooklyn
Queens
Flushing
Oyster Bay
Long Island Sound
Atlantic Ocean
Staten Island
Jamaica Bay
Jersey City
Hoboken
Weehawken
Fort Lee
Hackensack River
Passaic River
Pulaski
Oswego
Syracuse
Utica
Albany
Troy
Schenectady
Amsterdam
Little Falls
Rome
Oneida
Canastota
Buffalo
Rochester
Batavia
Niagara Falls
Lockport
Medina
Tonawanda
Erie Canal
Barge Canal
Delaware River
Delaware & Hudson Canal
Delaware & Lackawanna R.R.
Erie R.R.
New York Central R.R.
Lehigh Valley R.R.
Pennsylvania R.R.
Ontario
Lake Erie
Lake Ontario
Lake Champlain
Lake George
Lake Placid
Adirondack Mts.
Green Mts.
Berkshire Hills
Taconic Mts.
Catskill Mts.
Shawangunk Mts.
Hudson Highlands
Palisades
Ramapo Mts.
Watchung Mts.
Orange Mts.
Palisades Interstate Park
Delaware Water Gap
Water Gap
Stroudsburg
Easton
Phillipsburg
Bethlehem
Allentown
Reading
Harrisburg
Lancaster
Philadelphia
Trenton
Camden
Wilmington
Baltimore
Washington
Annapolis
Chesapeake Bay
Potomac River
Susquehanna River
Schuylkill River
Delaware Bay
Cape May
Cape Henlopen
Cape Charles
Norfolk
Virginia Beach
Richmond
Petersburg
Roanoke
Lynchburg
Charlottesville
Fredericksburg
Alexandria
Arlington
Mount Vernon
Blue Ridge Mts.
Shenandoah Valley
Shenandoah River
James River
Potomac River
Chesapeake & Ohio Canal
Norfolk & Western R.R.
Southern R.R.
Baltimore & Ohio R.R.
Pennsylvania R.R.
Virginia
West Virginia
Maryland
Delaware
New Jersey
Pennsylvania
New York
Connecticut
Rhode Island
Massachusetts
Vermont
New Hampshire
Maine
JANUARY 1910

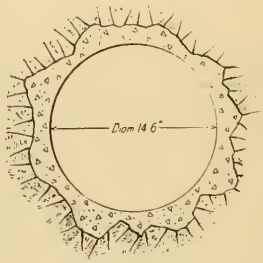

PROFILE OF CATSKILL AQUEDUCT
Miles from Ashokan Reservoir
0
10
20
30
40
50
60
70
80
90
100
110
1000
ASHOKAN RESERVOIR
Elev 390.
RONDOUT CREEK
WALLKILL RIVER
HUDSON RIVER
MOODNA CREEK
Sea Level
CROTON LAKE
KENSICO RESERVOIR
Elev. 355
Old Elev 295
HILL VIEW RESERVOIR
Elev. 295
NEW YORK CITY
HARLEM RIVER
Hydraulic Gradient
10 Story Building
EAST RIVER
NARROWS
Elev. 250
SILVER LAKE RESERVOIR
Pipe line to Queens not shown
-1000
120



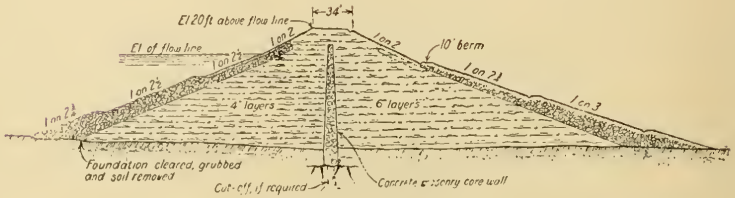
CUT AND COVER AQUEDUCT



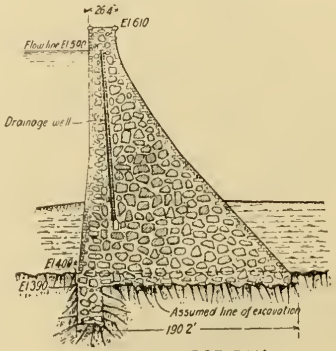
GRADE TUNNEL



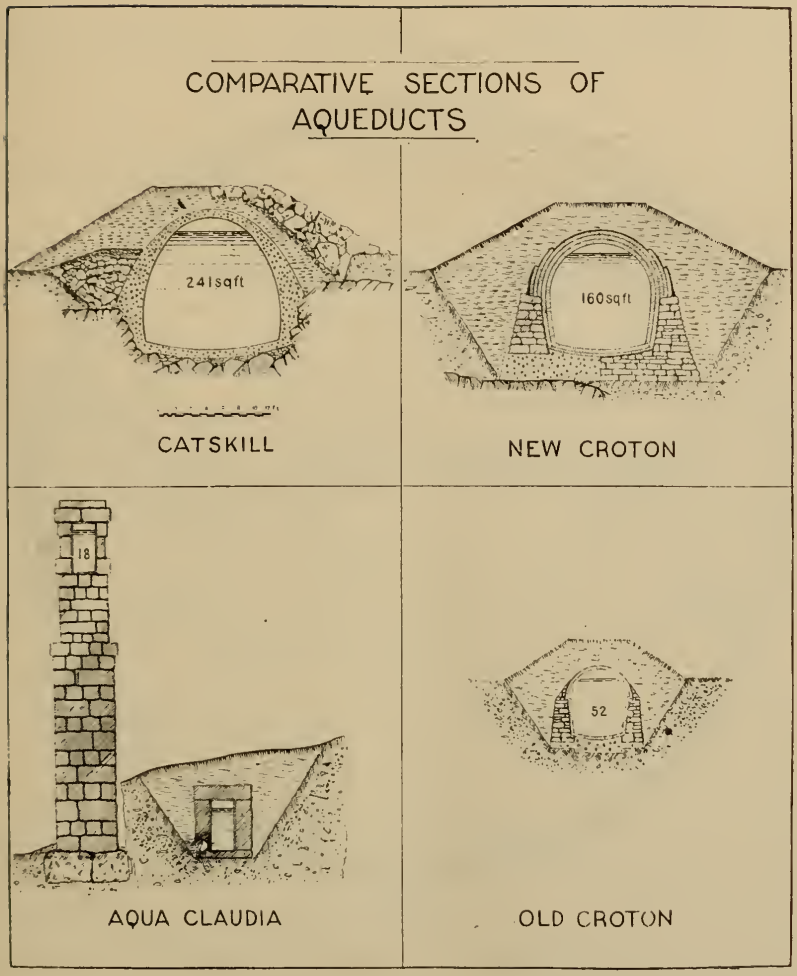
PRESSURE TUNNEL



TYPICAL SECTION OF DIKE



OLIVE BRIDGE DAM
MAXIMUM MASONRY SECTION


COMPARATIVE SECTIONS OF AQUEDUCTS
241sqft
CATSKILL
160sqft
NEW CROTON
18
AQUA CLAUDIA
52
OLD CROTON

The Hudson River is crossed by a siphon tunnel, 14 feet in diameter, which was bored through solid rock about 1100 feet below the surface of the river. The character of the rock in the river bed was investigated both by vertical borings and by inclined borings, made from the shafts (Fig. 1).

The aqueduct begins at the Ashokan Reservoir on Esopus Creek, which will have a storage capacity of 130,000,000,000 gallons, and

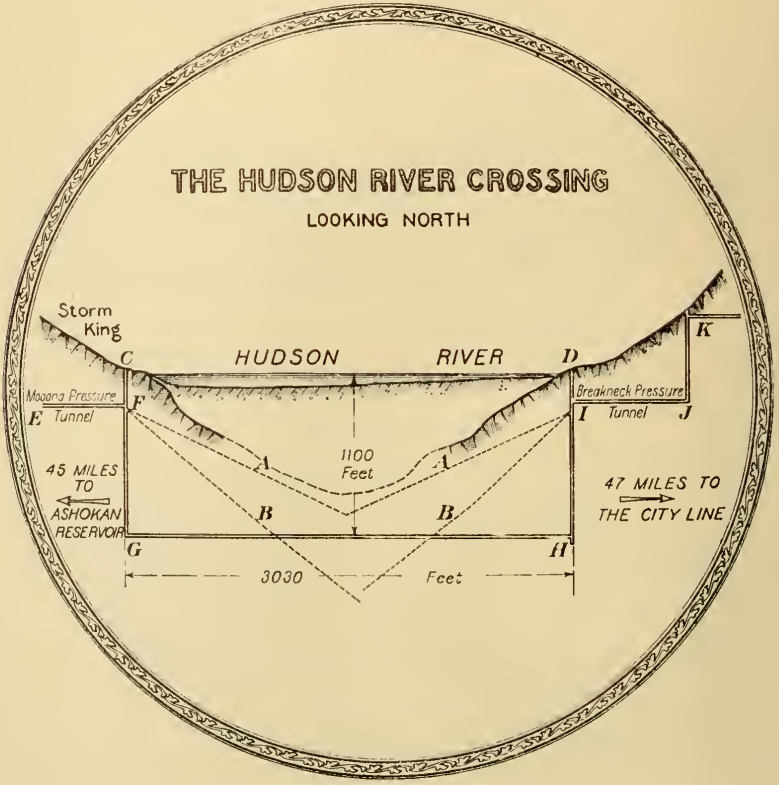


Fig. 1

terminates at the city line, at the Hill View Reservoir, which will store 900,000,000 gallons.

To provide for emergencies, the Kensico Reservoir is being constructed on the Bronx River, 30 miles north of the city hall. It will store 40,000,000,000 gallons.

From the Hill View Reservoir the water will be distributed to the different boroughs through circular pressure tunnels, 11 to 15 feet

in diameter, which are to be excavated deep below the streets in solid rock. From two terminal shafts in Brooklyn steel and iron pipes will convey the water to the boroughs of Queens and Richmond. The total length of this distributing system is 34 miles.

The works now in course of construction will cost about $200,000,000. The supply from Esopus Creek will only average about 250,000,000 gallons per day. In the future, additional reservoirs will be constructed to obtain another daily supply of 250,000,000 gallons from the creeks in the Catskill mountains.

The Catskill water works, briefly mentioned above, are of such magnitude and involve so many details that it would require a large volume to describe them fully. In conclusion it may be said, that in comparing the water works of ancient and modern times, it will be seen that while the same principles apply to both, the advance in the art of tunnelling and the materials now available for making pipes enable the modern engineer to locate his aqueducts on much shorter lines than could be adopted in ancient times. As regards building high arcades of dry masonry, some of the works of the Romans have stood for more than twenty centuries and could not be surpassed at the present time.

FLOOR AREA UNIT AS A BASIS FOR ESTIMATING CONSUMPTION

By William W. Brush

In 1908 the writer was placed in charge of the general design of the delivery system to carry to the five boroughs of Greater New York the 500,000,000 gallons per day which would eventually be available from the Catskill watersheds, this work being carried on by the Board of Water Supply. Studies in connection with the design of this system required a determination of the existing consumption in each borough, and in subdivisions of each borough, as well as an estimate of probable future growth in consumption.

It was found that the measurements of flow that had been made were not sufficient in extent to give a fair basis for estimating the present consumption in the various sections of the city, and that a per capita basis for consumption was practically useless for this purpose for the borough of Manhattan, due to the fact that large areas are wholly devoted to office buildings, manufacturing and other business purposes; and also due to the rapid changes going on in the elimination of buildings previously used for residences and the substitution of office buildings, lofts and factories.

While the water consumption of both large and small communities is generally expressed as the average amount supplied "per capita," this unit is used more on account of its convenience than for its usefulness as a basis to determine consumption in different sections of a city or for comparison of consumption in different towns and cities. The census, national and state, which is usually taken at intervals of five to ten years, gives data from which the population can be determined with a reasonable degree of accuracy and the per capita consumption readily calculated. It is evident that this unit is not one that gives an accurate standard for comparison, as the conditions as to kind and extent of manufacturing and other industries, character of buildings used for residential purposes, character of population, density of population, etc., affect the amount of water required for a community, exclusive of the amount lost through waste. In examinations made of the per capita consumption in different sections of large cities, variations of several hundred per cent have been shown,

due to the above causes. The highest consumption for domestic use is generally found in the highest class apartment houses, and the lowest consumption in the lowest class of tenements.

To carry out the work required to satisfactorily design the Catskill delivery system, some unit of consumption was necessary that did not vary to the extent of the per capita unit and that could be applied to business as well as residential sections. An investigation of the available data on which to estimate future as well as present consumption, showed that the area occupied by buildings would be the fundamental basis for future consumption, especially in the borough of Manhattan, and that, other things being equal, the amount of water used in any building would be dependent upon the ground area covered and the number of stories in height. It was therefore decided to study the use of the floor area unit as a basis for estimating consumption. The floor area was to be determined by multiplying the ground area of a building by the number of stories, allowing one additional story for basement or cellar. One thousand square feet of floor area was found to be a convenient unit, and one that would give a resultant consumption averaging about three times that figured on a per capita basis. There was no record that the floor area unit had been previously used in other cities and therefore no data was available for comparison of results obtained by the use of this method in New York City, although in a few instances the consumption had been determined on the basis of the ground area covered by buildings. The consumption per service, consumption per fixture, consumption per unit of length of main, and consumption for other units have also been computed in special cases.

The main reasons for adopting the floor area basis for New York City are summarized as follows:

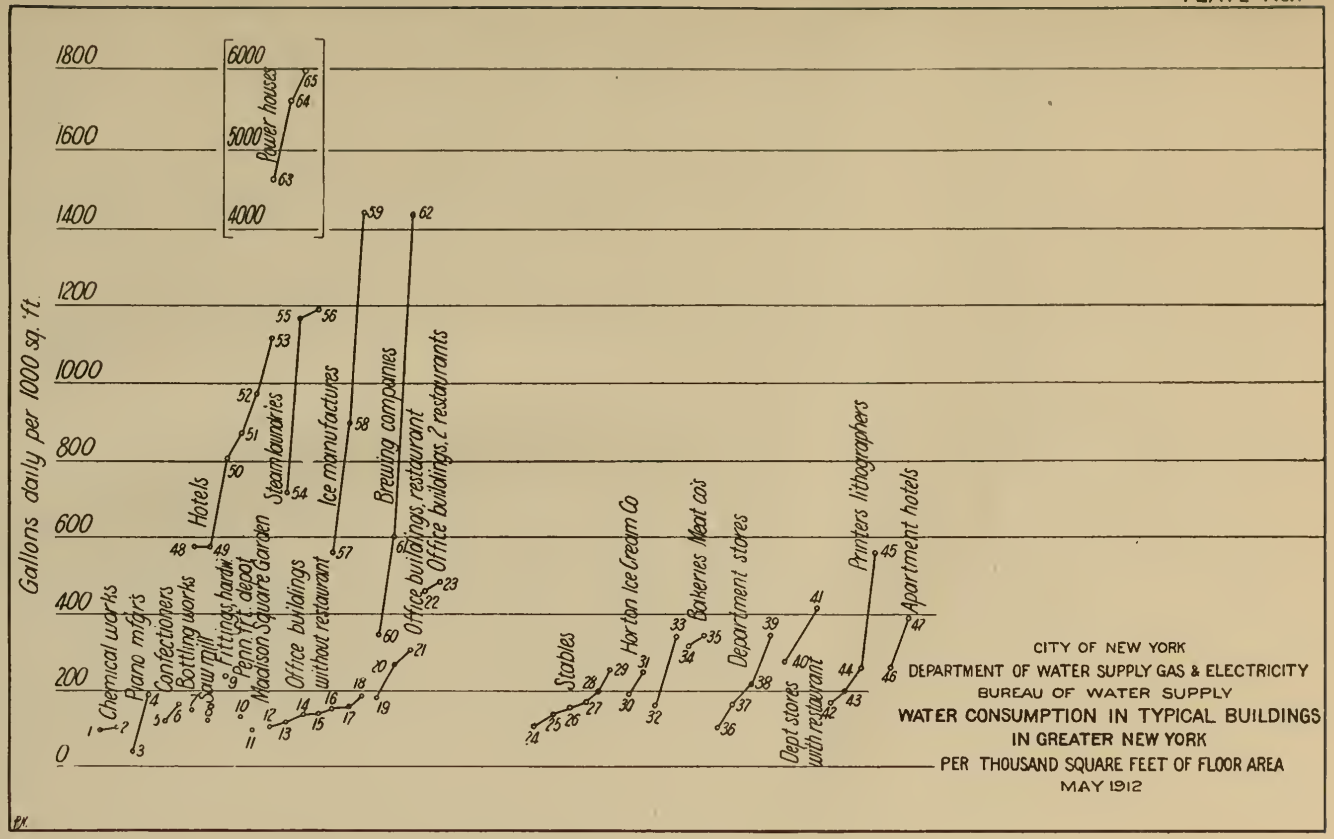
1. The amount of water used in any building is proportional to the size and height of same.

2. The total floor area could readily be obtained from available atlases.

3. The very large areas, especially in Manhattan, occupied only for business purposes.

4. The large and increasing population, especially in Manhattan, which is transient, and therefore cannot be accurately determined for the present nor for the future.

5. The presence of several hundred thousand people in Manhattan, engaged in business, who make their homes in adjoining sections of New York State and New Jersey.


Gallons daily per 1000 sq. ft.
1800
1600
1400
1200
1000
800
600
400
200
0
6000
5000
4000
Power houses
1 Chemical works
Piano mfg'rs
Confectioners
Bottling works
Saw mill
Fittings, hardw
Penn Yt. depot
Madison Square Garden
Office buildings without restaurant
Steam laundries
Hotels
Ice manufactures
Brewing companies
Office buildings, restaurant
Office buildings, 2 restaurants
Stables
Horton Ice Cream Co
Bakeries
Meat cos
Department stores
Dept stores with restaurant
Printers lithographers
Apartment hotels
CITY OF NEW YORK
DEPARTMENT OF WATER SUPPLY GAS & ELECTRICITY
BUREAU OF WATER SUPPLY
WATER CONSUMPTION IN TYPICAL BUILDINGS
IN GREATER NEW YORK
PER THOUSAND SQUARE FEET OF FLOOR AREA
MAY 1912

To determine the present use of water per unit of floor area, typical buildings were selected in which the supply was measured by meters, and the resultant consumption determined (Plate No. 1). There were also available, measurements of various districts in Manhatttan, Brooklyn and the Bronx, which were made by use of the pitometer during waste investigations carried on in 1902–1903. The following table gives the results of these measurements, as well as those taken in 1911, a reduction in consumption in 1911 of about 15 per cent having been effected by house to house inspection, prior to the measurements being taken, while in 1902 no special work had been done on water waste prevention:

Gaugings, 1902–1903

NO. OF DISTRICT	CHARACTERISTICS OF OCCUPANCY	CONSUMPTION	POPULATION RESIDENT	CONSUMPTION PER CAPITA
		m. g. d.		
1	Large hotels, high class residences	1.87	8,396	223
2	East side tenements	1.44	38,906	37
3	East side tenements	5.40	90,000	60
6	Residence and high class apartments	0.76	10,164	75
8	Business, office buildings, waterfront, shipping	9.45	11,000	860
9	High class apartments and hotels	1.37	8,872	154
10[1]	East side tenements, some waterfront	20.20	218,023	93
11	Uptown residences and medium class apartments	4.89	4,380	112
12	Upper east side tenement, waterfront, power houses and breweries	2.75	39,969	69

Gaugings, 1911

1a	East side tenement, some waterfront (same as district No. 10)	11.44	230,500	50
2a	All classes	29.48	204,557	144
3a	High class apartments, and residences	22.18	186,990	118
4a	High class apartments, residence and tenements	12.74	138,800	92
5a	East side tenement and waterfront	8.28	84,580	98
6a	High class apartments, residences, tenements and waterfront	14.82	173,000	86
7a	All classes	13.38	169,100	79
8a	All classes	13.66	209,393	65

[1] An error was later discovered in the measurement of flow in this district, which reduced the consumption as given by about 50 per cent.

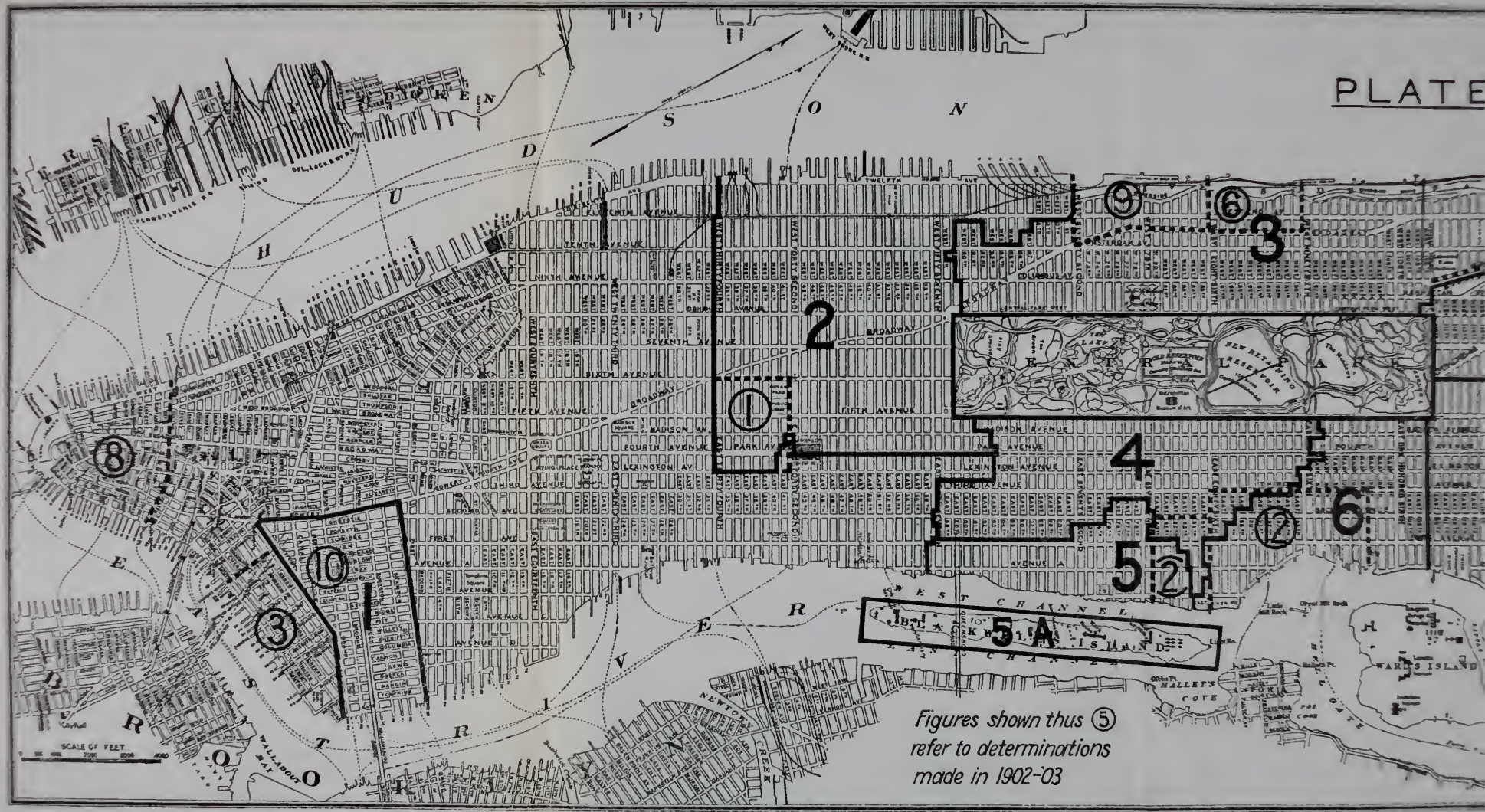
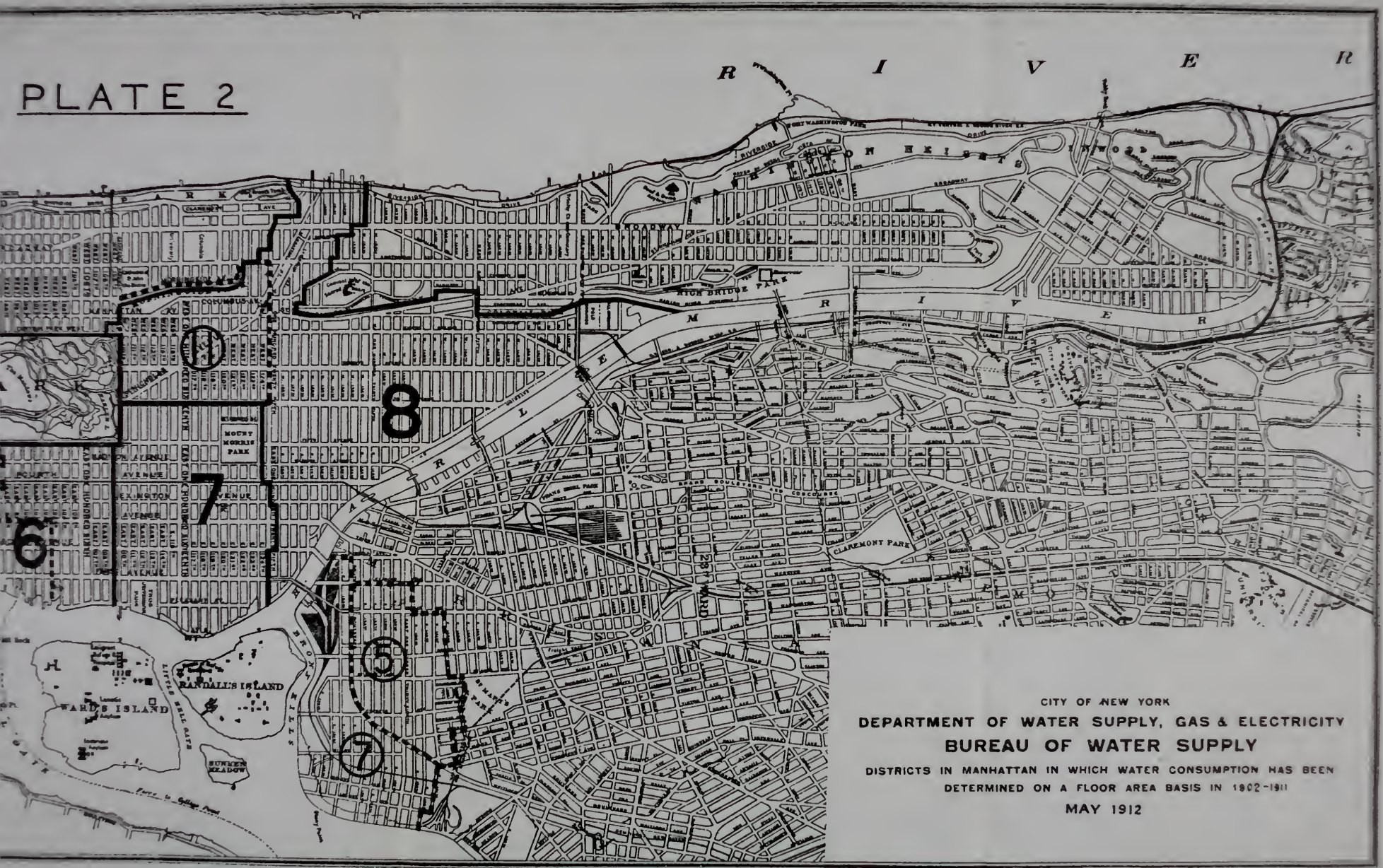


PLATE
1
2
3
4
5
5A
6
7
8
9
10
11
12
CENTRAL PARK
Figures shown thus ⑤ refer to determinations made in 1902-03

PLATE 2



CITY OF NEW YORK

DEPARTMENT OF WATER SUPPLY, GAS & ELECTRICITY

BUREAU OF WATER SUPPLY

DISTRICTS IN MANHATTAN IN WHICH WATER CONSUMPTION HAS BEEN DETERMINED ON A FLOOR AREA BASIS IN 1902-1911

MAY 1912

The above districts are shown on Plate No. 2, and the consumption plotted on Plate No. 3.

With a variation in the per capita consumption of from 37 gallons to 860 gallons daily, it was evident that it would be difficult to apply a per capita basis to different sections of the city to determine the consumption in such sections.

It was found, upon examination, that, with the exception of those buildings where the consumption of water would be unusually high, such as hotels, laundries, ice plants, etc., the use of water per 1000 square feet of floor area was generally between 150 and 300 gallons per day. This covered only those buildings used for business purposes, as under the rules of the water department, meters are not required in buildings used for residences. It was anticipated that apartments of the higher class would show a somewhat larger use of water per unit of floor area than would the tenement class, and that both would show a larger use than private residences. The first computations made of consumption in districts which covered several blocks, included a high class apartment house and hotel section in the vicinity of 80th Street, on the west side, and a low class tenement section on the east side in the vicinity of 80th Street. The per capita consumption in these two districts was 154 gallons per day and 37 gallons per day, respectively, the high class apartment district therefore showing a consumption, on per capita basis, of over 400 per cent of that shown for the tenement house district. On the floor area basis, the figures for these two districts were 181 and 179 gallons per day per 1000 square feet, respectively, or a variation of less than 2 per cent between the two districts. While this close agreement in consumption for the two districts was a coincidence, it strikingly illustrated the uniformity obtained from the floor area basis as compared with the per capita basis in two residential districts where the character of population varied widely. As further studies showed the floor area basis to be a practical one, it was applied generally to the borough of Manhattan. The ground area was scaled from the atlas, and this area multiplied by the number of stories, the buildings being grouped as far as possible to reduce the labor. It was found that it required the equivalent of about one man's time for four months to determine the floor area for this borough, the area in each block being estimated separately. After the entire area of the borough of Manhattan had been determined, the average consumption was computed and proved to be about 300 gallons per 1000 square feet.

To determine the prospective use of water in the borough of Manhattan, the area available for buildings was determined, eliminating street and park areas, and the borough was divided into four groups, the average height of building and percentage of ground area to be built upon in each group being estimated. The future consumption per 1000 square feet of floor area was taken as 350 gallons for that section of the city lying below 59th Street, to provide an ample margin of safety in the estimates. The following gives the units adopted:

SECTION	AVERAGE HEIGHT OF BUILDING, STORIES	PERCENTAGE OF BLOCK BUILT UPON	CONSUMPTION PER 1000 SQUARE FEET OF FLOOR AREA. GALLONS DAILY
South of 23d Street	8	85	350
23d to 46th Street	10	85	350
46th to 59th Street	8	85	350
59th Street to Spuyten Duyvil	6	75	300

These figures gave an ultimate estimated consumption of 835 million gallons daily.

In addition to estimating the ultimate consumption in the borough of Manhattan, the present and prospective use of water in the various sections of the borough were estimated, as a foundation for studies of the size of connections for the new Catskill aqueduct.

The experience of the past three years has shown that the floor area basis is useful also in the following work:

1. To determine what is the reasonable consumption in districts which are being surveyed by use of the pitometer, thus determining whether further investigations to detect leakage are advisable.

2. To determine consumption in individual blocks, or groups of several blocks, where it is proposed to extend high service to cover districts previously supplied from low service.

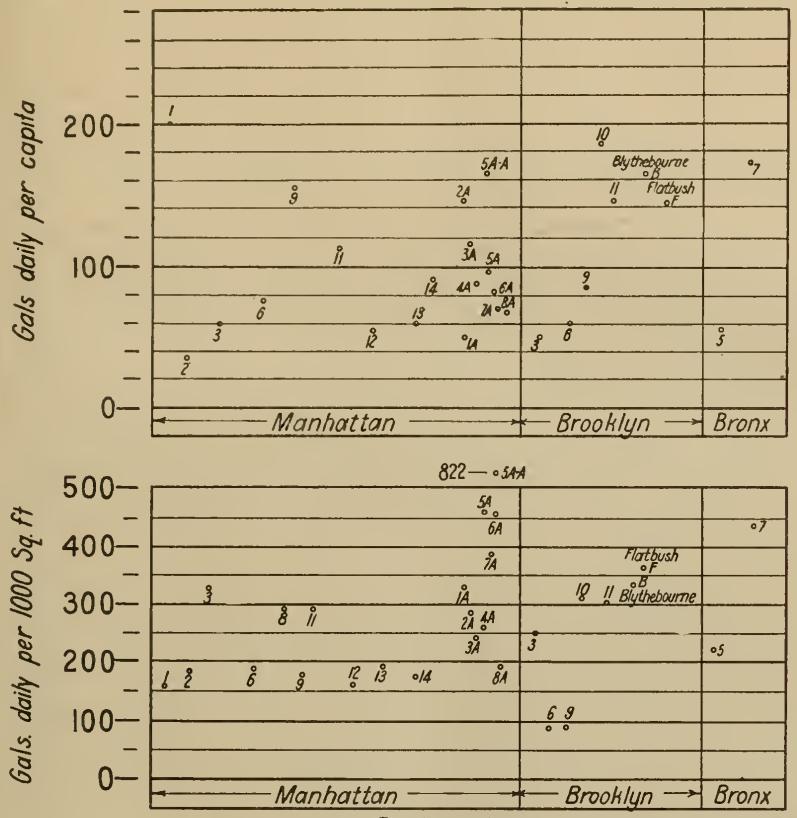
3. To determine whether metered consumption indicated for large buildings is probably correct, where question has arisen as to the presence of illegal connections.

4. To determine size of tap that should be granted for a new building.

The following illustrations of the use of the floor area basis in connection with gaugings of flow into districts and the use of water in buildings, are of interest:

In measuring the flow of water into district No. 10 in 1902–1903, an error was made in the direction of flow through one of the large mains included in this

PLATE No. 3



Dist.	Boro.	Description
8	Manhatt	Offices
6, 9 & 3A	"	High class apartments
1, 5A, 1A, 6A, 7A	"	Hotel & moderate "
13 & 14	"	Dept. store & residences
2, 3 & 12	"	East side tenement & water front
6 & 9	Brooklyn	Residences
F & B	"	Suburban dwellings
3	"	Tenements
11 & 10	"	" & manuf. plants
5 & 7	Bronx	Moderate cost flats
2A	Manhatt.	All classes
4A	"	Residences & tenements
8A	"	Residences, moderate class apartments & tenements

District numbers are those given on plates No 2 and 3 and annual report of Dept. of W G & E for 1903.
Approximate floor area Manhattan 825 Million sq ft
" population " 2,332,000
Consumption 246 M.G.D. Per capita 105 gals. Per 1000 sq. ft. floor area 298 gals.

CITY OF NEW YORK
DEPARTMENT OF WATER SUPPLY GAS & ELECTRICITY
BUREAU OF WATER SUPPLY
WATER CONSUMPTION IN TYPICAL DISTRICTS
IN
GREATER NEW YORK
PER CAPITA
AND
PER THOUSAND SQUARE FEET OF FLOOR AREA
MAY 1912

district. The flow in this main, which was about 5 million gallons daily, was taken as into the district, whereas it should have been taken as out of the district. The resultant error was, therefore, about 10 million gallons daily or about equal to the actual flow into the district. The resultant per capita consumption was 93 gallons, and was not considered to be abnormal. When the floor area unit was applied to this district, it was found that the consumption per 1000 square feet was over 600 gallons per day, whereas no other district had been found where the consumption had equaled 400 gallons, and few had exceeded 300 gallons. Investigation and subsequent measurements of flow in the district clearly showed the error, which was only discovered by applying the floor area unit.

The question of the presence of one or more illegal connections between the city's mains and the piping system of one of the large hotels was brought up. It was found that to measure the flow in the street mains and thus check the meters in the building would necessitate several taps, and the size of the mains was such that the rate of flow would be too small to give a reasonable degree of accuracy in the readings that might be obtained. To make the necessary taps and take readings would have cost several hundred dollars and would have interfered with traffic on two of the most congested streets in the city. A comparison of the use of water in this building on the floor area basis with that of several other buildings of like character, showed that the building in question used more water than any of the other buildings and, therefore, was conclusive, that the full amount of water supplied was probably passing through the meters.

The per capita basis for estimating consumption is the most practical one for general use, and will undoubtedly continue to be the standard unit. Experience with the floor area basis in New York City has shown, however, its usefulness in water works operation, and it is believed that other cities than New York will find occasions where the floor area basis can be utilized to advantage.

DISCUSSION

Mr. T. C. Phillips: The speaker would like to ask Mr. Brush whether he understood him to say that New York City was making studies to determine the size of the tap to supply certain buildings based on floor area.

Mr. William W. Brush: Yes, a table has been worked out for New York City by the department of Water Supply, Gas and Electricity, showing the size of tap to be granted depending on the floor area of the building to be constructed. We have not previously had any reasonable basis on which to grant the tap. The size of taps has been heretofore granted on the basis of the number of feet front of

the building irrespective of its height. Now, if you take into consideration both the frontage, depth and height of the building one can tell, we believe, reasonably well what amount of water would be used in the future in that building and therefore what size of tap should be granted. As a rule cities generally find it difficult to lay down any rules to govern the sizes of taps for buildings.

Mr. Alexander Potter: Has the city made any investigation or differentiated anything as to the character of use to which the building is to be put, such as loft buildings and hotels for instance?

Mr. William W. Brush: We have determined the amount of water used in typical hotels, loft buildings, office buildings, etc., and we propose to use that as a guide in determining the size of the tap; in fact, it was used as a guide in making the tentative table which has been spoken of, which however has not been put into use but is under consideration. There are few buildings which run above 1000 gallons per day per 1000 square feet of floor area. It is only in hotels, ice plants, breweries, power houses, and such places where it runs over 400 gallons. It seldom runs below 150 gallons. In office buildings, for example, if there is not a restaurant in the building, it will run about 150 gallons per day per 1000 square feet of floor area. In a hotel like this hotel, if the use of water is the same as that of a similar hotel in New York, it runs about 600 to 800 gallons per day per 1000 square feet of floor area. If you have no basis to go on other than frontage of the building you have very little idea as to what size of tap is reasonable, and the owner of the property comes to you and wants a 4-inch, or a 6-inch, or whatever size he thinks he may be able to get, and you have practically nothing to rely on to determine the proper size of tap unless you determine it on some basis similar to that which has been spoken of. It seems to us who have made a study of it in New York that the floor area basis is a reasonable one, and the only one that we have found that seemed to fit the conditions fairly well. We all know that no man can tell within perhaps 100 per cent of what the use of water may be in a building because he does not know necessarily what the character of the occupancy will be in a given number of years from the time the application is made; but the floor basis gives a fairly accurate basis.

Mr. Edward S. Cole: The speaker made the tests in 1903 to which Mr. Brush has referred, under Mr. N. S. Hill, Jr., then engineer

of the water department of New York City, and he thinks he can understand the difficulties under which Mr. Brush has labored. In the speaker's opinion he has devised in this floor area plan an excellent basis for dealing with metropolitan conditions; and the speaker thinks great credit is due to Mr. Brush for bringing out this new basis of comparison as a substitute for the old per capita basis. District No. 8 takes in all of Manhattan Island south of Fulton Street, and is an office building section. In 1903 we made a careful census of all office buildings. We counted the number of floors in each building and obtained the transient population during the business hours for each floor giving us the per capita use based on total and on residential population. At the same time we did what we consider to be of more value, that is we not only counted the number of floors and transient population but we made a very careful estimate of the horsepower of the power plants in each of these office buildings. Many of these office buildings in our large cities maintain an immense steam plant, not only for driving the elevators, etc, but for heating in the winter, and of course the use of water is dependent upon the horse power used. We therefore inventoried the boiler horse power in each building, and presented it in our tabulation, with an estimate of required water consumption.

The speaker would like to ask Mr. Brush if in his later work the horse power of the buildings enters into the computation of the floor area consumption? It would seem in the light of our own experience that this is quite an important factor. No doubt it was considered.

Mr. William W. Brush: In the work that we did we did not consider the question of the power plants in the buildings. In the office buildings we did not consider the question of restaurants although those buildings in which there are restaurants use more water than those in which there are none. The speaker has some figures which show the unit of consumption by floor area in some of the well known New York large office buildings where they have power plants, and in some where they have not. Take the Park Row Building, it is twenty-six stories in height, and there is a restaurant and refrigerating plant for the restaurant and also a drug store in that building, the latter using 2200 gallons daily. The power plant develops 2900 kilowatts daily, and they use 338 gallons per 1000 square feet of floor area. In the Singer Building 95 gallons is used per 1000 square feet of floor area for boiler consumption, whereas the total for the building is 311 gallons per 1000 square feet of floor area. That building

has no restaurant, but it is one of the most recent of the large office buildings, and probably is as extravagant in the use of water through fixtures as any of the New York buildings. The Royal, is a smaller building of modern type and only uses 102 gallons daily per 1000 square feet of floor area, because it obtains its power from the Edison Company, and therefore does not use any water for power purposes. The question of whether a building uses power or not is important when you are determining the size of the tap; however, you have to take an average use of water, because you are uncertain as to what may be the future occupancy and power plant of the building, but you have to determine the size of taps on a liberal basis. Of course in fixing the size of the tap you do not want to keep water from being used where it is needed.

Mr. Edward S. Cole: The speaker happens to remember that on several occasions we found large meters in those buildings in New York "out of order," but as a matter of fact they were in full operation, and here is where this method must be used cautiously. When making comparisons with meter readings you must make sure that the meters are in proper condition. To illustrate my point we found in one district a 4-inch meter reported "dead." Its dial was not moving but the disc was running at full speed. These things have to be looked out for in getting the basis for ascertaining the standard water consumption per unit per floor area.

Mr. T. C. Phillips: Was the amount of water consumption which was used as a basis to determine the consumption per unit of floor area measured by districts in all instances?

Mr. William W. Brush: Yes, sir.

Mr. T. C. Phillips: Did you use meter measurement in checking the consumption per unit of floor area in any class of buildings?

Mr. William W. Brush: We used meter measurements for the buildings, or classed the buildings originally upon the water used according to meter measurements so far as practicable. After having determined that, we divided the buildings into different classes, grouping them originally by class of occupancy, and we based our ultimate figures of consumption upon the results of the district figures rather than upon individual building figures as determined by meter registration of consumption in those buildings.

MR. T. C. PHILLIPS: The consumption of water in Manhattan, south of Fulton Street, is practically all metered, is it not?

MR. WILLIAM W. BRUSH: Not all, but in great part.

MR. T. C. PHILLIPS: Did you check the meter measurement against the pitometer measurement in determining the consumption per unit of floor area south of Fulton Street?

MR. WILLIAM W. BRUSH: We used pitometer measurements rather than the meter readings in the books, but we can not readily determine the meter consumption in New York districts in which there are a large number of buildings. The pitometer measurements in commercial districts showed a consumption per capita of something over 800 gallons, whereas on the basis of floor area it was somewhere around 300 gallons, if the speaker remembers the figures correctly. At all events it tallied pretty closely with the determination in other districts.

MR. T. C. PHILLIPS: You found 800 gallons daily per capita consumption by pitometer measurement for the resident population south of Fulton Street, Manhattan?

MR. WILLIAM W. BRUSH: On the resident population only, yes.

MORE THAN FIFTY YEARS' REMINISCENCE IN WATERWORKS

By H. G. H. Tarr

When a man has reached the age where his experiences pass back beyond the memory of those with whom he is associated, his mind becomes retrospective. This is a very great privilege, and I have often envied the last survivor of the Civil War as I recount my experiences from '61 to '65, and think what a heroic figure a soldier could carve out of himself if he had no one to check off the events.

Personal experiences, however, are of no value here except so far as they relate to our common pursuit, so in this g'ance back of half a century over the field of waterworks construction in all its details, my aim, in the main, is to compare what we are doing today with the practices of the past, to determine, so far as we can, how much progress we have made.

Bear in mind that you are pursuing a profession that is older than we know the history of man, so old that we have but the ruins of great aqueducts to inform us that hydraulic engineering was a profession ages back.

In this, you are wholly unlike the electrical engineer, or he who builds the great power plants, for they are dealing with elements that were practically unknown a century ago, and the development of which has been almost entirely within the time of which I speak. You are simply studying to do each year better work than the year before, and each generation better than the preceding one, and it is by evolution, not startling new discoveries, that you reach your end. Yours is a profession which deals with the uplifting of the man far more than theirs, as cleanliness, we are taught by the Scriptures, is akin to Godliness. To you is intrusted the lives of the urban population of this entire continent. The bacteriologist may chase down in his laboratory the typhoid germ, or some other deadly foe to human life, but it remains with you to exterminate him and guard against these invading armies that are threatening every community and whose victims number, despite all your watchfulness and skill, more than all the wars of the world. In view of this, it is not wholly for your pleasure that we halt on our onward march, and from this height look back-

wards upon the road by which we have attained this eminence, but in part, for encouragement and renewed strength for greater endeavor.

Thus looking back to my first introduction to a waterworks job, in 1857, I can think of but one man living who was then active in work of this character, and I am not quite sure of him, so you will observe, that in my earlier experiences I am on safe ground. It will be considered, however, that I was interjected into the situation very early in life, whereas the active list were then young men.

It happened in this way. By the death of my father in California, in 1853, I was removed from that promised land, then in its virgin state, and brought to Brooklyn, a suburb of New York. My uncle, Moses Lane, an engineer on the original Brooklyn waterworks, undertook the thankless task of shaping my education, and generally bringing me up; a sort of continuous colt breaking performance, with which I fear no one was entertained.

During the school term this was comparatively easy, as he divided his responsibilities with the master. But in vacation time, the problem in a small city with a swimming hole as big as the East River, and its fleet of ships with beautiful yard arms to dive off of, was too much for any one man to do, and do well. So, in despair, he put me with one of the field parties out at Baisley's pond to be cuffed around by a half dozen young engineers. I could drag a chain, drive a stake and carry water as well as a full grown hand. It was here that I got my first experience in pumping and conveying water, as when at home, my special chore was to fill and carry six or eight buckets of water from the public pump on the street corner to the house a long block away and this had to be done every morning before I went to school. With this service, I can fairly say that my waterworks experience began more than one half a century ago.

It is interesting that in this period I held the tape and helped stake out the location of the original Ridgewood pumping station, and over forty years later, as manager of the pumping engine department of the Worthington Company, was concerned in the building of the new station at that location, but with a vastly different character of engine.

The Brooklyn waterworks was considered, and it was a great work for that day, second only to the Croton of New York, and I remember how the natives of Long Island viewed it with wonder. One of them stopped my uncle when I was with him and said, "Mr. Lane, all this bringing water from way up the island seems nonsense to me. Why don't you build the works all right here?"

Mr. Lane replied by asking how he would do that.

"Why," he said, "first build some good substantial sheds all over the top of that hill, catch the water and let it run down into the city."

"But," said Mr. Lane, "the surface of your sheds would be much less than the surface of the reservoir. Why not catch it there?"

The chief engineer of this work was James P. Kirkwood, a Scotchman and a most distinguished engineer, but engineers were not so plenty in those days, and, therefore, became distinguished on less provocation than now, as they herd together in their great societies. I believe, though, that he was all they say of him, for he gave me a five dollar gold piece once, as a tip.

It was he who made the original plans for the present Cincinnati system and laid out the site of the great California station which I had the honor to contract for for my company, half a century later. The vacation field experience was followed by my being apprenticed to the Woodruff and Beach shops in Hartford, who were building the Brooklyn engines. What a marvelous difference between a machine shop of fifty years ago and one of to-day. In no one particular has the development of this great age been more marked than in machine tools, the parent tool of all the wonderful machines made. In the old days the machinist must do most of his work with a cold chisel and file, and the first year of an apprentice was spent in knocking the skin off his knuckles and breaking his back lifting castings, as a machinist's helper, for there wasn't a shop crane in the place.

We were then building the engines for the gunboat Kearsarge and the work was rushed to the limit, so we had to put in fourteen to eighteen hours a day, but how proud we felt two or three years later, when she sank the Alabama off the coast of France, that we had each made some small part of the gallant little gunboat.

We were also building the original Brooklyn engines which represented the very highest type in design and construction then known to the art. They were of the vertical flywheel type and among the very first to depart from the lumbering old Cornish engine. The vertical triple expansion flywheel engine of today is simply an evolution from this engine, peg by peg, and it will be interesting to compare the costs and performance of the two. They were of seven million gallons capacity. I do not know the weight, but it was fully equal to a fifteen million engine of today, and the guaranteed duty was 70,000,000 foot pounds with 40 pounds steam pressure, and it was a well known secret that she never attained it, but did so "wonderfully well" that nothing

was said about it. The cost of this engine without boilers was $125,000. It will be interesting to compare this engine with one of the present day, and we will take the last engine built for Pawtucket, R. I. This is known as the Reynolds type, practically the same as Boston, Cincinnati, St. Louis and many other cities in this country; and is the most economical in steam consumption of any engine of whatever character known to the world today. It has 15,000,000 gallons capacity and is about half the weight of the old Brooklyn and shows economic duty of 176,000,000 foot pounds with 150 pounds steam. In other words, the progress in fifty years has been twice the capacity, two and a half times the duty and about four times the steam pressure, at forty per cent less cost, or stating it a little stronger, an engine then doing 70 millions duty, cost $18,000 per 1,000,000 gallons rated capacity, and to-day, one doing 176,000,000 costs five thousand dollars per 1,000,000 gallons rated capacity, at practically the same head. It is further interesting to note that to-day, a 7,000,000 gallon engine of the horizontal type, against the Brooklyn head, will sell for about $14,000 or $16,000 and the maker will guarantee you a duty of 125,000,000 foot pounds, about 10 per cent the cost of fifty years ago, with nearly twice the efficiency. It is interesting to record here that the highest duty yet attained by any engine is 194,000,000 foot-pounds per thousand pounds of superheated steam with 95° of superheat. As 198,000,000 is theoretically equal to 1 pound of coal per indicated horse-power, it may also be said that a steam engine has reached the limit in economy.

The war came on then, and during most of its progress I was serving in the Union Army. When peace was declared, more than half a million men full of enthusiasm for work were out of employment. Colonels became street car conductors and captains drivers. I remember very well seeing a man punching tickets as conductor on a little jerk water railroad, whom I had seen at the head of an army corps, a major general, surrounded by a brilliant staff, orderlies and standard bearers, until he looked bigger than the Duke of Wellington. But after the war he had to get down to work, and there weren't good jobs enough to go round.

I went to inspecting pipe. They were then casting them vertical in dry sand moulds and horizontal in green sand. The latter were in nine foot lengths and mighty rough and uneven in thickness at that. I am under the impression that no green sand pipe were used after about 1870 excepting in the very smallest sizes, two and three inch.

The Brooklyn specifications were the classics of that day, and are

quoted even now, and it may truly be said that they did more to improve the quality of pipe than anything else. A large proportion of these pipes were bought in Scotland. The Scotch foundries, however, were not in competition with us here after 1860.

Under these specifications there was more rigid inspection than ever before. In fact, it was the beginning of careful inspection of pipe that has been growing more and more rigid until the requirements now are almost beyond reason; in fact, quite so in the hands of an inspector who does not exercise sound judgment.

It will be interesting to hark back and see what pipe shops there are now that have been in existence half a century or nearly so. In the east, that is east of the Alleghanies, the R. D. Wood foundries at Millville, N. J., the Warren at Easton, Pa., and the Camden Iron Works, now a part of the Wood organization, but then owned by the Star family, are the survivors. In the west it was an exceedingly primitive industry. Dennis Long had built his foundry here in Louisville, which remains a splendid monument to a grand old man. Gaylord built his Cincinnati shops soon after the close of the war, and manned it largely by moulders from Warren and Wood. Out of this has grown the Addyston. Shickle, Harrison and Howard built a big foundry for the day at St. Louis, and ran it for twenty five years or so, moving to Birmingham with the advent of cheap iron there. E. P. Allis built a shop in Milwaukee, but he was handicapped by freights east and south, and the northwest wasn't sufficiently developed then to support a pipe shop. The Columbus Foundry was built to east their pipe when the new waterworks was constructed, about 1872. The only surviving foundry in the west, of fifty years ago, is Dennis Long and Company, and of those along in the seventies, the Buffalo and Columbus. I say Buffalo, as they belonged to the old western pipe association.

Curiously there was a pipe shop at what is now the famous resort, Lakewood, N. J., then called Bricksburg, and it ran up to 1872 or 1873. It was claimed that they made the first pipe cast in America from the New Jersey bog ores.

The price of cast iron pipe from way back up to what is known as the Jay Cook panic in 1874, seems incredible today. I was engaged for a number of years in selling cast iron pipe, and a very interesting business it was, too. Think of it. In 1872 Pittsburgh paid $85 a net ton for thousands of tons of 36-inch water main made extra heavy for their pressures. The local foundry that took the contract paid the western associated foundries money and tonnage to keep out, and

their *internal tax* is said to have been very heavy. This western association had an ingenious method of procedure. Every contract was auctioned off at a meeting of the manufacturers previous to the letting. First, they fixed the price which it should go at, and this was $5 or $6 above cost and a *fair profit.* Then the bidding came for the privilege of becoming the low bidder. Usually, this brought $6 or $8 a ton into the pool. Periodically, this money was divided up among the members, each receiving in proportion to the capacity of their foundry. Just now, when trust builders are criminals, it is interesting to note that this association printed a book stating their purposes, by-laws, mode of procedure and names of officers. In 1873, just before the Jay Cook panic, I slipped in under the nose of these fellows and took a contract for 8000 tons from Toledo at a ruinous price, $68 a net ton, and what was worse, we had to take our pay in their city bonds bearing only 7 per cent interest. These were fine old Robin Hood days when the words graft and trust had not been invented except as applied to simple horticulture and absolute faith.

The Jay Cook panic, however, put a stop to all this kind of thing. Pig iron went down from over $50 to about $20, pipe accordingly, and it became a survival of the fittest, and, curiously enough, they nearly all survived, showing that combinations and graft are not at all necessary to existence.

The high cost of iron up to 1874 or 1875 brought into waterworks construction the substitutes for cast iron pipe, and in every city it was iron against wood or iron against cement, depending upon locality. In new construction, where they were without previous experience, they used enormous quantities of these substitutes, especially cement, in some towns for their entire system; and I venture to say many of you have replaced miles of it and wondered what were the conditions under which it was laid in preference to cast iron. In most cases, I can tell you now, *graft,* for the town of that decade could teach the city of today all there is to learn in this gentle art.

One of the most interesting eras in the history of waterworks in this country was that from 1880 to 1895, about fifteen years of speculative building. Very many of the towns and some small cities were wholly without a water supply early in this period. As an example I built the works in Woonsocket, R. I., in 1885. It was then rated at twenty two thousand inhabitants with its millions of dollars of mill property; yet there was absolutely no water supply.

Waterworks bonds found a ready sale, and schemers, as well as many good reliable men, sought franchises, and, in most cases, ob-

tained them on very liberal terms, too many of them being given without any adequate protection to the community. I remember one man who was a boiler salesman. He bloomed out as a capitalist in a year with offices in New York and a staff of clerks, engineers and henchmen building at one time six or eight works, borrowing money by the hundreds of thousands. He expanded until his balloon burst, and a committee of creditors had the sad duty of reporting that his constructions in many cases had been largely veneer. In one instance, I remember the bond holders found when they came to take possession of the plant that along miles of supposed pipe line upon which they had advanced money as the work progressed, the hydrants were set in post holes and not a foot of pipe laid between them.

Despite the fact that most of the works had been constructed along legitimate lines, with the breaking up of three or four builders (one of them owning the waterworks in twenty-two cities), waterworks securities lost character, as a whole, and were looked upon with distrust. It is gratifying, though, to be able to say that the very high characters of those who survived, have redeemed them.

This era in which almost every town then existing in the country was supplied was followed by one of outrageous attacks of unscrupulous and fanatical people upon private water companies, as well as other public utilities. This was greatly aided by several court decisions, mostly in the west, that were almost equivalent to confiscation. Many of you will remember the Gresham decision by which it was declared that the temporary taking off of water pressure from any cause whatever, forfeited the charter of a water company. In this day of public agitation against trusts and public utilities, I doubt if there is any more appreciation on the part of the people of all your effort to serve them, or if vested interests of this character are any safer than they were in the past, and there are few positions in life where more diplomacy and patience must be exercised than that of a waterworks superintendent, especially in the management of a private company. A good man will have every dog in the town barking for him and his company. A tactless man will make enemies and ruin an investment. I remember one case and in a large city, too, where the investment was nearly a million dollars. The bonds and stock were way above par. The company had everything its own way and felt sure of the renewal of its contract, which was soon to expire. An Irish woman who kept a boarding house came in to beg the superintendent not to cut her water off; her boarders were on a strike and she couldn't pay just yet. He was rough with her and cut

off the water. She appealed to the alderman of her ward, a fighting Irishman. He started the fight, and it spread like a prairie fire. The contract was not renewed. The city exercised its right to buy, and the company received eighty per cent of its bonded indebtedness, while the stock, over a half million, was entirely wiped out. I was drawn into it to try and save the situation, but too late; however, I learned beyond doubt that the disaster was entirely due to tactless management, and the match was lighted in turning off the Widow McGinness' water.

It is probable that the Centennial exhibition of 1876 did more to bring together engineers (as well as other professions) and those of kindred interests than anything else, as during its progress there were assemblages there of representatives of nearly every profession, and out of these grew many permanent associations. This association, however, was not organized until 1881. The original call for it was issued by W. C. Stripe of Keokuk, Ia., and the first convention held in St. Louis, Mo. The success and usefulness of the association has been notable from the start. It went through the infantile diseases successfully, and there wasn't one of them it escaped.

Of later years it has not been my good fortune to attend the meetings, and looking over this assemblage I am impressed at the great change that has taken place in the personnel of the association. Of the older members few remain. Many are dead, and some grown so old in the service that they have passed their work over into younger hands. I recall the names of Colonel Foster, president for the first two years; dear old Gardner of New Orleans who last year passed over to the other shore; Peter Milne, genial, quiet and so earnest in all your deliberations. Decker, your first secretary, then president, was my assistant in New York for a number of years and our business relations are among the pleasant memories of my life. Then Jimmy Donahue, who owned the Davenport works, and who was everybody's friend, and so on, too many to mention, but whose names will be remembered in the association so long as the old ones are here, and be a tradition when they have gone. Diven, who like the poor, ye have always with you, succeeded Decker as secretary and served until 1891, when he was passed up to the presidency. Colonel Gardner explained it by saying that Diven was made president because he was "such a doggon poor secretary," but in 1902 he resumed that important work and here he is and I suppose you have gotten so used to him that you can't get on without him. How can we think back without associating with these old managers of works, some who for years

This was the initiative step in getting up the "American Water Works Association" — The idea was entirely my own — W. C. Stripe

S. P. POND, PRESIDENT. W. C. STRIPE, SEC'Y & ENG'R.

KEOKUK WATER WORKS.

Keokuk, Iowa, Jan. 18th 1881

Dear Sir:

Having been requested to take the initiative in calling a Convention of Superintendents of Western Water Works, you will confer a favor by advising me by return mail whether the project meets your approval—whether you will attend, and at what city you would prefer the Convention to be held.

Respectfully yours,

W. C. STRIPE.

Superintendent of Water Works.

March 20. 1882
The second Annual Convention was held Mch. 14. 15. 16 which proved to be a grand success — The Association has become a National Affair

Eureka!

have come on business bent, and without them, there wouldn't be any fun; besides this, they are exceedingly useful, as well as very dear to you all. I refer to such as "Colonel" Brown and Shepperd of *Fire and Water Engineering*, with many others I could name.

Finally, looking backward one half a century, let us pause in our rush, rest a while and ask what are the great material and social changes that we see? Briefly these: A vastly more efficient and economical management in every particular in public water supply, and an equal advance in purity. I mean purity of water and purity in public morals (with which you have so much to do). Filtration and care of sources of supply have worked wonders in public health. Exposures and education in public morals have brought about important results in driving out the worst of pests, graft and corruption. Twenty or thirty years ago in awarding contracts and granting franchises these were the all potent factors. Today they are evils so seldom practised that they need no longer be feared. Thus. my old and new associates, year by year, and peg by peg you have bettered the conditions necessary to a healthy life of the people. As your mission is a high and holy one, and as you gather here with a full feeling of the responsibility you each owe to your communities, you will no doubt go back to them having garnered a measure of new ideas from your brethren, and more than that, with renewed strength and fitness for further great endeavor.

DISCUSSION

Mr. John Caulfield: Because the speaker's hair is turning white he does not want you to class him with Captain Tarr. At the time the Captain refers to he was sixteen years of age, and entered the water works business in 1870. He remembers the first pipe we laid, the main conduit was of cement and the balance was cement lined pipe. Some of you older members may remember it, or rather you may have run across it especially throughout the east, sheet iron lined with cement. After it was laid it was covered with cement on the outside. We have some of that pipe in use to this day. It was all right at that time on account of the great cost of cast iron pipe. In our city the water works mains were laid before the sewers were built, and when the sewers were put in, of course, there was a settling of the pipe cracking the cement on the outside, permitting moisture to enter and causing rust. Cement pipe, however, that was laid forty-three years ago is still in existence. The speaker can remember some

of the cast iron pipe that we bought from Dennis Long in 1870 and paid $90 a ton for. Captain Tarr's reference to E. P. Allis brings to mind the fact that before he went into the pump business he was in the foundry business, and we bought some of his pipe in 1872.

In regard to the improvements in pumping machinery, you remember, you who have some of the old pumps still in use, that we only obtained from them 35,000,000 to 40,000,000 duty. In 1883 one of the concerns brought out a pump of 85,000,000 duty. Of course there was a great deal of competition among the various agents and one of the agents—poor man he is dead now—told us all about the working parts and what it cost to keep the machinery in order, and of course almost convinced the members of the water board; but the representative of an opposing company, who was not a practical mechanic, was afraid to trust himself and he brought his old superintendent up, who was a man that was very convincing although he was an everyday sort of a man. The board heard the various representatives in public, so that if one man made a complaint against the machinery of the other it would give an opportunity for the latter to contradict the statement. This old gentleman referred to was really the inventor of the pump, and was the last one to speak; there were four or five bidders. When he got up he said, "Gentlemen, if you buy any of these pumps you won't be swindled, they are all good pumps." The speaker can remember seeing one of the members of the board look over to him and wink his eye approvingly. He liked that kind of talk and he took to the man at once. Then he spoke about repair parts and the expense of repairs, and he offered to give a bond for twenty years that the expense of repairs should not exceed 2 per cent a year. Of course that settled all opposition on the other side; they quit. The bond was given, and there has not been a dollar spent on those pumps in twenty-nine years.

Five or six years after that we let a contract for another pump on which there was a guarantee that the cost of repairs for twenty years would not exceed three-quarters of 1 per cent annually, and there has not been a dollar spent on it. The duty has run 140,000,000; but at the pumping station here I see that they tested 177,000,000, so I do not know where the limit is going to be in pumping machinery.

Mr. Stuart Wood: Mr. President and Gentlemen, the speaker is not in the habit of reminiscing. The fact is he has not got used yet to considering himself as an octogenerian, like Captain Tarr or Colonel

Caulfield. Still possibly there may be one or two things that may come to his mind.

A good many of us at one of our recent meetings had the pleasure of visiting New Orleans, and we went over the splendid plant which the city of New Orleans has installed there.

The speaker's initiation in the pipe business was on the occasion of the first attempt to rejuvenate the New Orleans water works after the civil war. It was in 1879. The old company had done nothing for many years. The principal streets of the town were, many of them, laid with pipes of 4 to 6 inches in diameter, and many of them were half or two-thirds full of mud. There was no water pressure worth speaking of. The rehabilitation of the plant was intrusted to that grand old man to whom Captain Tarr alluded, Moses Lane. The speaker went down from Philadelphia, and there was quite a little convention of the older men in the pipe manufacturing business. There was old Dennis Long and his son-in-law, Sam Miller, Tom Howard of Shickle, Harrison & Howard of St. Louis, Tom Gaylord of Cincinnati, owner of the Newport Foundry, and, altogether, there were five or six of us who spent a week or two there very pleasantly at the St. Charles Hotel. I remember Mardi Gras came along and Jefferson Davis was in attendance. Do not know whether he came there to see the Mardi Gras or because of his interest in the water works men.

That contract was let at what the speaker believes was the lowest price that had ever been paid for cast iron pipe. It seems almost incredible, but the figure that runs in my mind is $17.17 a ton, instead of the $80 or $90 which was attained a little earlier or a little later. Such are the fluctuations in water. You know water easily fluctuates.

The speaker will tell you of another letting which was indicative somewhat of the period of which Captain Tarr spoke. It was at St. Louis a few years later. They had been in the habit of sending out invitations to some of the manufacturers in the neighboring territory, extending possibly as high as the falls of the Ohio River or a little farther. These pipe men then used to have their little gatherings all to themselves, and somehow or other, when they came away one or other of them had the contract at a very satisfactory figure. The city engineer was a little dissatisfied, and he wrote a letter urging the speaker to come out there. He did; he came there in the utmost secrecy. He didn't even register at the hotel. He was intro-

duced to a gentleman, a real estate agent, who was a friend of the chief engineer of the city of St. Louis. He wrote out a bid and left it with the real estate man, and so that his presence there should be entirely unknown he took the train to Springfield and spent the night in Springfield studying history. The bids were opened at twelve o'clock the next day. Exactly as the clock struck the hour, he walked into the room. His bid had been deposited by the real estate agent. The faces of the others, instead of broadening with pleasure at his arrival, as they should have done, lengthened when they first saw him enter, and lengthened further when they found that his concern was the successful bidder for 600 tons of pipe. In order to get a living freight rate, we sent that pipe from Philadelphia to New Orleans by schooner, and it was afterwards carried by river steamboat, from New Orleans to St. Louis.

The speaker does not know whether we can take counsel or wisdom from an old associate in our firm at a little earlier date than that of which Captain Tarr speaks. It was about the close of the civil war. Our old partner was a reflective man. He had been a school teacher in his early days, and he had studied statistics and history, and so he figured it out that the cities of the country were about filled up with cast iron pipe, and that from that time out the foundries might expect a dwindling business. He therefore withdrew from the partnership, as he did not wish to imperil his fortunes by remaining in a business which was going to fall away to nothing. Of course since that time most of the foundries that are now in active operation have been erected.

In the earlier days, there were no special foundries for the making of pipe, but here and there little charcoal blast furnaces began to make pipe as well as other castings in order to dispose of their output. This was especially the case in New Jersey, and from these small beginnings the present business was developed. The speaker has in his possession a newspaper of the date of 1813, which contains the description of such a furnace, out of which finally grew our own pipe foundries. It had just been put in operation, and its owners advertised to the world in the Philadelphia newspaper, calling attention to the fact that it was situated at the head of navigation of Maurice River, by which also it was furnished with water power; and, last but not least, the advertisement states that it had on hand the enormous amount of one hundred tons of pig iron for sale. All over the pine woods of New Jersey there were scattered little furnaces and forges of this kind. Some of them were situated on tidewater and could send

out their product by vessel. Others less fortunately situated had to have their pipe hauled by team ten or twenty miles to the Delaware River in order to get it to market.

Of course, most of those old establishments have died out. Perhaps our own is the only one that originated in that manner, that is still engaged in making pipe.

Gentlemen, the speaker is obliged to you for your attention, and he hopes you will not put him in the class of those old men who have spoken before.

Mr. William Schwanhauser: Mr. President and Gentlemen, it was not a surprise to the speaker to find the Captain here, as he knew that the Captain was going to deliver an address, and being anxious to hear him came all the way from New York for that purpose. The speaker likes to be in his company, being an old scholar of his, having profited under his tutelage. The speaker was connected with him for many years when he was with the Worthington Company, and as he is still a member of that old organization we have a certain fellow feeling existing between us which the speaker hopes will last. As to experience in water works matters the speaker can tell you but very little. He has tried to become acquainted with the subject, and has been perhaps identified to some degree with the development of the Worthington engines; but once in a while he is told that it is only an overgrown feed pump. Of course he feels a little differently about it. The speaker had an opportunity at one time to see if that overgrown feed pump could not give the same duty as other types of water works engines. That, however, is a matter that perhaps you don't feel very much interested in.

The speaker has been very much pleased to learn of the wonderful progress in pump duty, starting with 40,000,000 and getting up to 176,000,000 and more. It shows what has been accomplished by the efforts of the many minds that have applied their energies to this subject. He knows every one of you is anxious for the very highest possible development along these lines, and assures you that this is a matter that affords great pleasure as well as study to himself.

The speaker has not attended very many of these meetings but will do so hereafter, because he finds men here that he would like to know better and hear from them just what is being done.

You have visited the new pumping station here where we made an attempt in the line of a world-beater. Starting from 25 r.p.m., and going up to 1500 r.p.m. is quite a step forward. Whether or not that

pump will prove its life and its efficiency is a matter for the future to determine. The speaker feels very thankful, however, to the chief engineer here, Mr. Leisen, who had the courage of his convictions and who adopted a system which is comparatively new but which however is very promising. We have carried out the work to produce and give him the machine that he wanted, and such men are the ones who bring about progress in these lines. Without them we may scheme all sorts of things, but unless we have someone who says to us, "Here, I believe that can be done and I will give you the opportunity to prove it," we cannot progress. With the aid of such men we do progress and are able to produce something that is a step in the right direction.

MR. JOHN M. DIVEN: The speaker wants to correct an impression that some may have. When we were paying $95 a ton for pipe it was for a gross ton.

CAPTAIN H. G. H. TARR: No, net. A curious custom existed in those days. Universally west of the Alleghanies it was the net ton, and east of the Alleghanies it was the gross ton.

MR. JOHN M. DIVEN: In the east we purchased by the gross ton; and the many divisions by 2240 are still a nightmare.

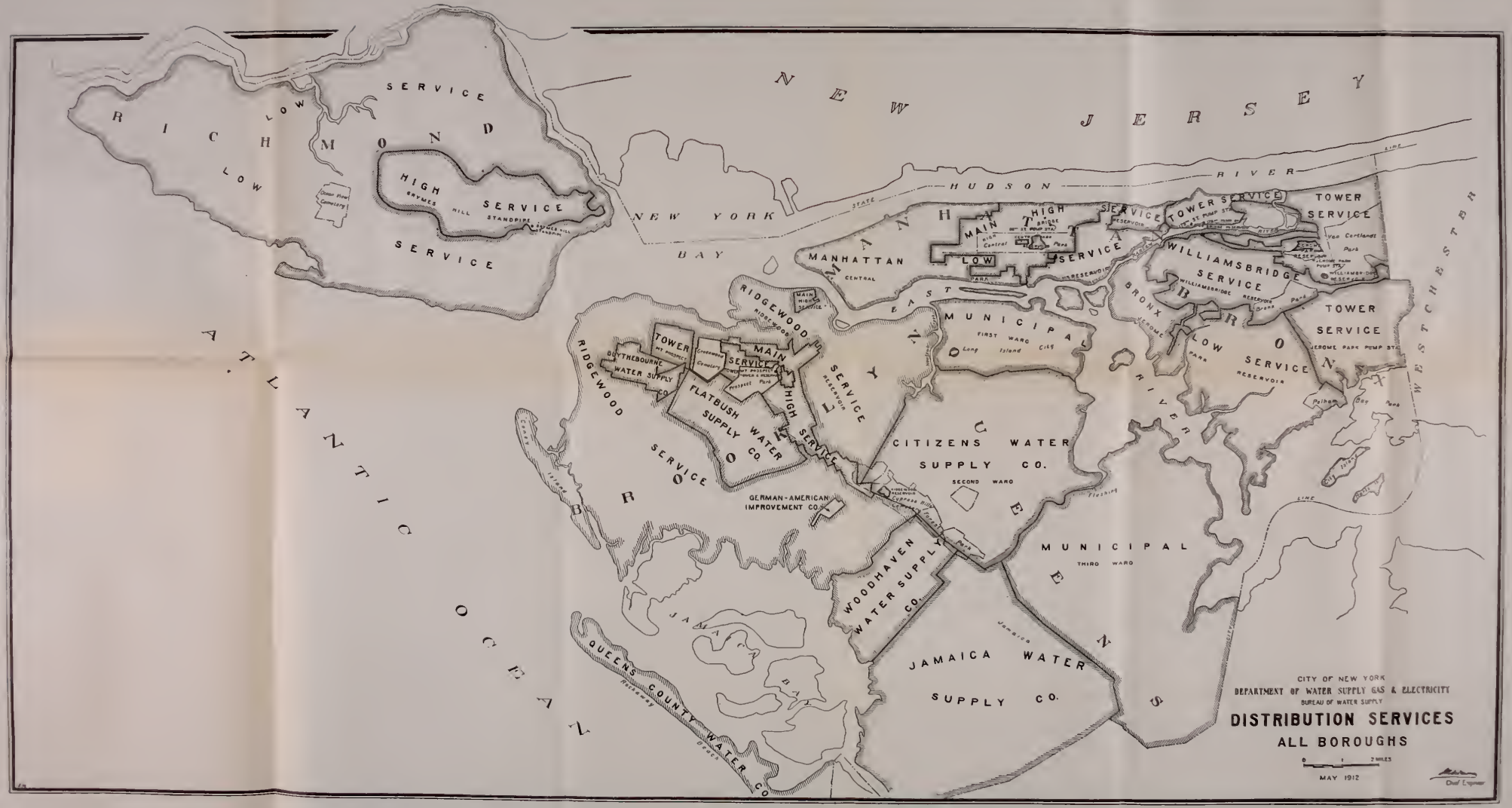

RICHMOND
LOW SERVICE
HIGH SERVICE
STANDPIPE
SERVICE
NEW JERSEY
HUDSON RIVER
NEW YORK BAY
MANHATTAN
MAIN HIGH SERVICE
LOW SERVICE
TOWER SERVICE
WILLIAMSBRIDGE SERVICE
BRONX
EAST RIVER
MUNICIPAL
FIRST WARD CITY
Long Island City
CITIZENS WATER SUPPLY CO.
SECOND WARD
BROOKLYN
RIDGEWOOD SERVICE
RIDGEWOOD
BUTTHEBOURNE WATER SUPPLY CO
FLATBUSH SUPPLY WATER CO
GERMAN-AMERICAN IMPROVEMENT CO.
WOODHAVEN WATER SUPPLY CO.
QUEENS
MUNICIPAL
THIRD WARD
JAMAICA WATER SUPPLY CO.
QUEENS COUNTY WATER CO.
ATLANTIC OCEAN
WESTCHESTER
CITY OF NEW YORK
DEPARTMENT OF WATER SUPPLY GAS & ELECTRICITY
BUREAU OF WATER SUPPLY
DISTRIBUTION SERVICES
ALL BOROUGHS
MAY 1912

PLATE I

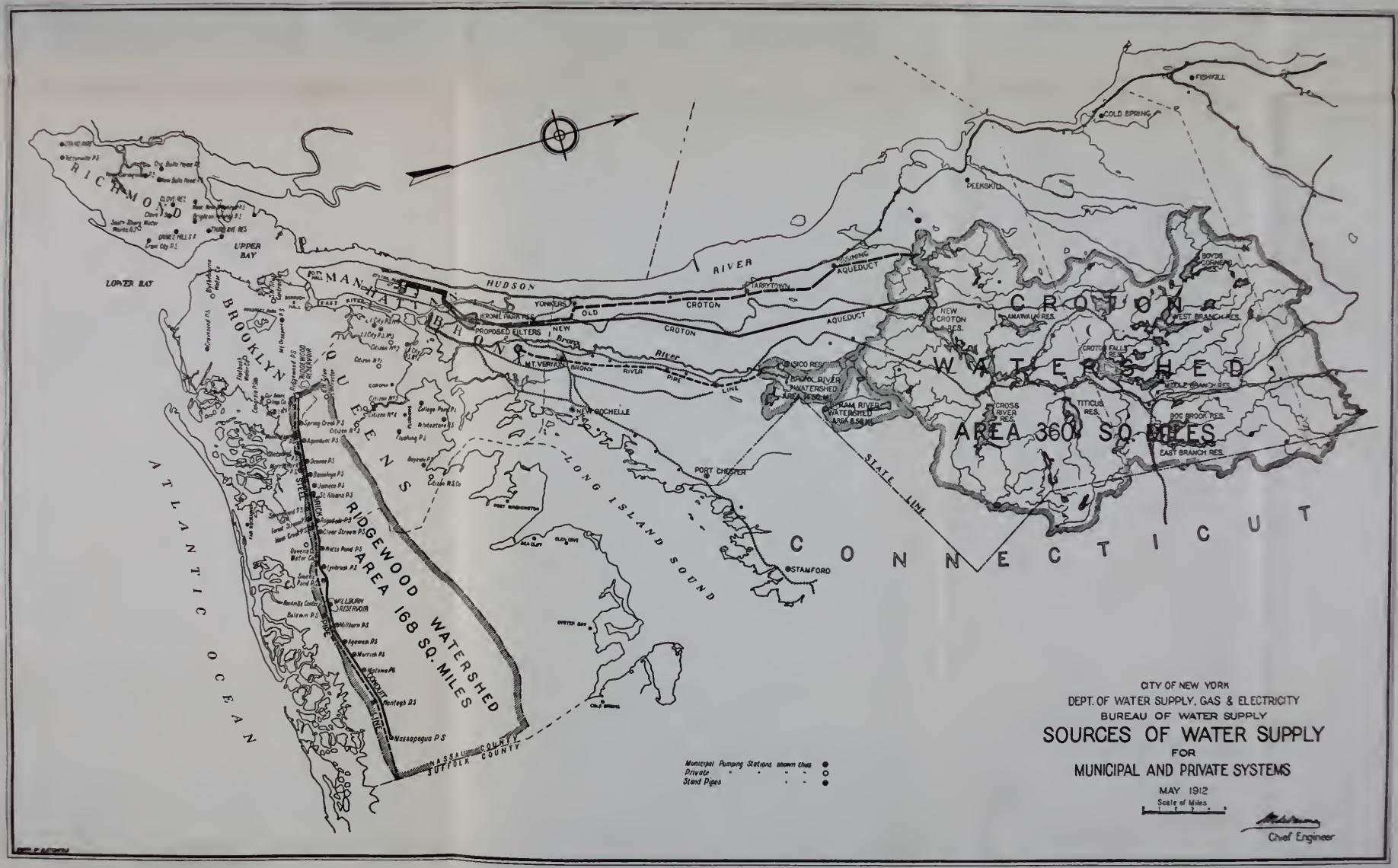

RICHMOND
UPPER BAY
LOWER BAY
MANHATTAN
BRONX
BROOKLYN
QUEENS
HUDSON RIVER
EAST RIVER
HARLEM RIVER
YONKERS
JEROME PARK RES.
OLD CROTON AQUEDUCT
NEW CROTON AQUEDUCT
PROPOSED FILTERS
NEW CROTON
Bronx River
MT. VERNON
BRONX RIVER PIPE LINE
NEW ROCHELLE
PORT CHESTER
LONG ISLAND SOUND
STATE LINE
CONNECTICUT
STAMFORD
ATLANTIC OCEAN
RIDGEWOOD WATERSHED
168 SQ. MILES
RIDGEWOOD RESERVOIR
WILLIAMSBURGH RESERVOIR
NASSAU COUNTY
SUFFOLK COUNTY
FISHKILL
COLD SPRING
PEEKSKILL
TARRYTOWN
CROTON WATERSHED
AREA 360 SQ. MILES
NEW CROTON RES.
AMAWALK RES.
WEST BRANCH RES.
CROTON FALLS RES.
MIDDLE BRANCH RES.
BOYDS CORNER RES.
TITICUS RES.
CROSS RIVER RES.
DOG BROOK RES.
EAST BRANCH RES.
BRONX RIVER WATERSHED AREA 8.5 SQ. MILES
KISCO RES.
RAM RIVER WATERSHED AREA 8.5 SQ. MILES
Municipal Pumping Stations shown thus
Private
Stand Pipes
CITY OF NEW YORK
DEPT. OF WATER SUPPLY, GAS & ELECTRICITY
BUREAU OF WATER SUPPLY
SOURCES OF WATER SUPPLY
FOR
MUNICIPAL AND PRIVATE SYSTEMS
MAY 1912
Scale of Miles
Chief Engineer

PLATE II

ORGANIZATION OF THE BUREAU OF WATER SUPPLY, CITY OF NEW YORK

By I. M. de Varona

The department of water supply, gas and electricity of the city of New York is responsible for the sufficiency and quality of the water supply, and has therefore jurisdiction over the operation, maintenance and extension of the existing systems for the five boroughs constituting Greater New York. The board of water supply, which is a separate organization, has charge of the development of the Catskill sources.

The general organization of the department is as follows:

Administration. The head of the administration bureau is the commissioner, with a deputy commissioner in charge of each borough.

Bureau of Water Supply. This bureau is under a chief engineer and has charge of the operation, maintenance and extension of the water supply system for the five boroughs.

Bureau of Lamps and Lighting. This bureau, under a chief engineer, has jurisdiction over lamps and lighting and electrical installations for the five boroughs.

Bureau of Water Registrars. This bureau has charge of the collection of water rates, the installation of meters and the supervision of the use of water within buildings.

Auditing Bureau. The auditing bureau has charge of the accounts for all the five boroughs.

Bureau of Supplies. This bureau has charge of the purchase, inspection and delivery of supplies for all boroughs.

To properly understand the organization of the bureau of water supply, a brief outline of the sources of supply for the five boroughs, and of the methods of delivery, pumping and distribution of the same, is necessary. Plates No. 1 and No. 2 show the system of water supply.

BOROUGHS OF MANHATTAN AND THE BRONX

These two boroughs are supplied from the Croton River and from the Bronx and Byram Rivers. The principal features of these watersheds, connecting conduits, pumping stations and distribution systems are as follows:

Source of Supply. (1) Croton River, first used in 1842; (2) Bronx River first used in 1884; (3) Byram River, first used in 1897.

Area of Watershed. (1) Croton = 360 square miles; (2) Bronx = 14 square miles; (3) Byram = 8 square miles.

Storage Reservoirs. In the Croton watershed there are 12 reservoirs which, with the natural lakes and ponds, give a total storage capacity, including flashboards, of 104,443 million gallons. Bronx and Byram watershed contains 4 reservoirs with a total storage capacity of 6026 million gallons.

Aqueducts. There are two aqueducts known as the "Old" and "New" Croton respectively.

The Old Croton Aqueduct is 34 miles long with dimensions of about 7½ feet wide and 8 feet high, giving a cross-section area of 53 square feet. It has a slope of 1.1 feet per mile and has a maximum capacity of 90 million gallons daily.

The New Croton Aqueduct is 31 miles long, of horseshoe shape, 13.6 feet wide and 13.5 feet high, giving a cross section area of 154 square feet. The slope is 0.7 feet per mile and has a maximum capacity of 300 million gallons daily. A 48-inch pipe, 15.2 miles in length, delivers the supply from the Bronx and Byram watershed to Williamsbridge Reservoir. It has a capacity of 18 million gallons daily.

Total aqueduct capacity, 408 million gallons daily.

Pumping Stations. There are four stations with an aggregate pump capacity of 155 million gallons daily. These pumped 76 million gallons daily during 1911.

Distribution Reservoirs. There are four distribution reservoirs with a total capacity of 2136 million gallons.

Distribution Service.

Manhattan	Consumption in 1911 m. g. d.
Low service gravity (water in Central Park Reservoir, elevation 118 feet)	187
Main high, or intermediate service (High Bridge Reservoir, elevation 220 feet)	54
Upper high or tower service (High Bridge Standpipe, elevation 324 feet)	5
Bronx	
Low service gravity (Jerome Park Reservoir, elevation 130 feet)	22
Williamsbridge, or intermediate service (Williamsbridge Reservoir, elevation 193 feet)	25
High or tower service (Jerome Avenue Pumping Station, standpipe, elevation 303 feet)	5

Distribution System. Consists of about 1300 miles of mains varying from 4 to 60 inches in diameter on which there have been set 23,740 gates and 20,300 hydrants.

Consumption. During the year 1911, the average daily consumption for Manhattan and Bronx was 298 million gallons for a population of about 2,838,400, which corresponds to a daily consumption per capita of 105 gallons.

BOROUGH OF BROOKLYN

The water supply for the borough of Brooklyn is mainly derived from city owned and operated plants, but there are three private companies owning and operating their systems within the borough limits. The supply is obtained from the watershed of the South Shore of Long Island, extending easterly to the Suffolk County line. The following table shows the main features of the Brooklyn system:

Source of Supply. Driven wells, infiltration galleries and small streams along the south shore of Long Island; this system first introduced in 1859.

Area of Watershed. Ridgewood watershed has an area of 168 square miles.

Storage Reservoirs. There is only one which contains over 50 million gallons. It is known as the Hempstead Storage Reservoir and has a capacity of about 850 million gallons.

CONDUITS	LENGTH	DIMENSIONS	CAPACITY
			m.g.d.
72-inch steel pipe	23 miles		50
Easterly conduit—brick (horseshoe shape)	7½ miles	East end—5 feet 11 inches by 7 feet 4 inches West end—6 feet 11 inches by 9 feet 4 inches	60
Westerly conduit—Milburn to Ridgewood Pumping Stations—pipe and brick (horseshoe shape)	15 miles (3 miles 48-inch and 36-inch pipe and 12 miles brick)	6 feet 4 inches by 8 feet 2 inches to 8 feet 8 inches by 10 feet	75
Two 48-inch mains	15 miles		50
Total conduit capacity	175 million gallons daily		

Pumping Stations. There are 31 stations with an aggregate pump capacity of 590 million gallons daily. These pumped 303 million gallons daily during 1911. The supply is all pumped once and portions thereof two, three or four times.

Distributing Reservoirs.	CAPACITY *million gallons*
Ridgewood (3 basins), 170 feet elevation	304
Mt. Prospect, 198 feet elevation	19
Mt. Prospect standpipe, 274 feet elevation	0.1
Total	323.1

Distributing Service.

	CONSUMPTION *million gallons daily*
Ridgewood or low service (Ridgewood Reservoir at 170 feet elevation)	111
Mt. Prospect or intermediate service, at 198 feet elevation	19
Mt. Prospect tower or high service (standpipe at 274 feet elevation)	10

Private Companies.

	million gallons daily
Flatbush Water Works Company. Supplies 29th ward (standpipe at 180 feet elevation)	12
Blythebourne Water Works Company. Supplies part 30th ward (four tanks at 140 feet elevation)	2
German American Improvement Company. Supplies small part of 26th ward (standpipe)	0.8

Distribution System. There are 967 miles of mains varying between 4 and 60 inches with 18,340 gates and 16,100 hydrants in the municipal system.

Consumption. The average daily consumption for the year 1911 was 155 million gallons daily from both the public and private systems, for a population of 1,710,000, which corresponds to a per capita consumption of 90 gallons daily.

BOROUGH OF QUEENS

The water supply for this borough is obtained from driven wells and is furnished by both municipal and private stations scattered throughout the borough. The following table gives the main features of the system:

Source of Supply. Driven wells (Public and Private Systems).

Pumping Stations. There are now five municipal pumping stations (one having recently been abandoned) with an aggregate pump capacity of 24 million gallons daily. These pumped 4.9 million gallons daily during 1911.

Distribution Service.

PUMPING STATION	SERVICE	PURCHASED FROM PRIVATE COMPANIES	TOTAL CONSUMPTION
	m.g.d.	*m.g.d.*	*m.g.d.*
1st ward,[1] L. I. City, No. 1 and No. 3.	1.5	7.7	9.2
2d ward, Citizens Water Supply Company			9.8
3d ward,[1] Whitestone, Flushing and Bayside Pumping Stations	3.7	0.5	4.2
4th ward, Jamaica Water Supply Company and Woodhaven Water Company			5.5
5th Ward, Queens County Water Company			2.9
Total			31.6

[1] In the 1st ward service, average elevation 145 feet, no distribution reservoirs or standpipes used while in the 3d Ward service, average elevation 172 feet, two standpipes with overflow elevation at Flushing of 218 feet and at College Point of 189 feet.

Distribution System (Municipal). Consists of 181 miles of mains varying in diameter from 4 to 30 inches on which have been set 2520 gates and 2015 hydrants.

Consumption. During the year 1911 the consumption from both public and private systems was 31.6 million gallons a day for a population of about 300,000, corresponding to a per capita consumption of about 105 gallons daily.

BOROUGH OF RICHMOND

The water supply for the borough of Richmond is obtained from driven well plants, which are owned and operated by the municipality, with the exception of one small plant. The following table shows the principal features of the system:

Source of Supply. Driven wells.

Pumping Stations. There are six permanent and one temporary station, with an aggregate pump capacity of 26 million gallons daily. These pumped 9.6 million gallons daily during 1911.

Distribution Services.

LOCATION	SUPPLIED BY	CONSUMPTION
		m.g.d.
Southern and Western portions	Tottenville Pumping Station (Standpipe elevation at 140 feet)	0.3
Highest levels of easterly and southerly portions	Clove High Service (limiting elevation—440 feet)	0.6
The remainder without any district divisions	Reservoir elevations: Clove, 250 feet; 3d Avenue, 209 feet	8.6
New Dorp	(Private Company) South Shore Water Works Company	0.1
Total		9.6

Distribution System. Consists of 202 miles of mains varying in diameter from 4 to 30 inches, on which have been placed 3320 gates and 1890 hydrants.

Consumption. The consumption during the year was 9.6 million gallons daily, for a population of 88,300, which corresponds to a per capita consumption of 108 gallons daily.

In addition, the bureau of water supply has control of the high pressure fire service system, which is used exclusively for the extinguishment of fires. The table on page 66 gives the main features of this system, which has been installed in Manhattan and Brooklyn.

When in 1898 what are now the various boroughs were consolidated into the Greater New York, all the public supply systems were placed under one chief engineer, with an engineer in charge of each of the boroughs of Brooklyn, Queens and Richmond. However, although there was only one chief engineer, there was no centraliza-

High pressure fire service systems

	MANHATTAN	BROOKLYN	
		Main System	Coney Island
When work of installation of system commenced	1904	1905	1904
Approximate cost of system	$5,550,000	$1,800,000	$160,000
Area protected	2222 acres	2600 acres[1]	250 acres
Miles of mains in place	94	34	6
Size of mains	8-inch[2] to 24-inch	8-inch[2] to 20-inch	8-inch[2] to 16-inch
Number of hydrants	2065	1100	150
Number of valves	3540	1530	200
Number of pumping stations	2	2	1
Number of units	12 (6 at each station)	8 (5 at main station and 3 at reserve station)	3
Total rated capacity	36,000 gallons per minute (at 300 pounds)	24,000 gallons per minute (at 300 pounds)	4500 gallons per minute (at 150 pounds)
Power	Electric motor power supplied by Edison Company	Electric motor power supplied by Edison Company	Gas
Cost of operation of pumping stations during 1911	$127,000	$90,000	$17,500

[1] Area protected includes a strip 600 feet wide outside of district in which mains are laid.
[2] 8-inch mains only used for hydrant branches.

tion of the work and the borough of Brooklyn maintained a separate and complete organization both for the design and construction of new works and for the maintenance and operation of the system. In 1902, an additional chief engineer was appointed. One chief engineer was then placed in charge of Manhattan, the Bronx and Richmond and the other in charge of Brooklyn and Queens. This latter borough shortly afterwards was grouped with Manhattan, the Bronx and Richmond and this form of organization was adhered to until the early part of 1908. Between that time and the latter part of 1909, the work was gradually parcelled and subdivided until finally there were no less than six independent heads, acting without concert or coöperation, and reporting directly to the commissioner, these divisions being as follows:

Chief engineer in charge of the water supply for the boroughs of Manhattan and the Bronx, but without having any jurisdiction over the high pressure fire service stations in Manhattan.

Chief engineer in charge of the water supply for the borough of Brooklyn, but with no jurisdiction over the high pressure fire service stations in that borough; also in charge of the inspection and meter reading division which is normally under the water registrar.

Supervising electrical engineer in charge of the high pressure fire service stations in Manhattan and Brooklyn.
Engineer in charge of the borough of Queens.
Engineer in charge of the borough of Richmond.
Chemist in charge of laboratory work.

Under such an arrangement there was no technical head to coördinate the work and to standardize methods of operation and maintenance, as well as new construction; each division was carried on in an independent manner, thus materially increasing the cost to the city; and the services of the more experienced and better qualified men in the department were available only for work of one division, which resulted in great loss in efficiency.

When Hon. Henry S. Thompson, the present commissioner, took charge of the department on January 1, 1910, he readily recognized the need of a radical change and directed the writer to take charge of the water supply work for the five boroughs and to prepare a plan of reörganization.

Some idea of the magnitude of this task may be given by stating that there were about 2500 employees then in the various engineering offices and divisions to be analyzed, changed around, assigned and replaced or displaced; that there were often several men filling the same position, thus rendering numerous transfers and discharges imperative; that in a few cases new positions had to be established; that extreme care had to be exercised and the utmost difficulties encountered in discriminating between conflicting claims, so as to recognize and promote efficiency while scrupulously avoiding injustice or unfairness; and that throughout all these changes the stringent regulations of the civil service commission had to be strictly adhered to and the exacting routine work of the department, as well as the work of construction, faithfully prosecuted without slack or intermission. By unremitting and conscientious labor, often extending long beyond official hours, the organization plan was, however, completed towards the end of February, approved in the early part of March, 1910, and put into effect about the twentieth of that month.

The underlying principles of this plan were as follows:
1. One responsible technical head.
2. Separation of operation and maintenance from construction of new work.
3. Centralization of design work.
4. Centralization of construction force.
5. Centralization of inspection of materials for construction.
6. Subdivision, along borough lines, of operation and maintenance, provid-

ing for central supervision to insure uniform standards for materials and methods of work.

7. Division of work of design, construction, operation and maintenance along functional lines, as far as such subdivision is economical and efficient.

Plate No. 3 shows the organization adopted. The experience of the past two years, together with the development of the filtration work has made it necessary to slightly modify the original organization, and the present organization is shown on Plate No. 4, omitting all secondary and minor subdivisions.

It will be seen that this organization provides for the chief engineer as the technical head, to whom report directly all the divisions having charge of design, construction and inspection, as well as the laboratory division. To relieve the chief engineer of the many details connected with operation and maintenance, the divisions having charge of this work, including the real estate division, report to the chief engineer through the deputy chief engineer. This subdivision of the work between the chief engineer and the deputy chief engineer is elastic, the chief engineer taking up directly important questions relating to operation and maintenance, and the deputy chief engineer taking up such questions relating to design, construction and inspection as directed by the chief engineer.

The design work has been divided into three functions, the laying out of the distribution systems and design of miscellaneous work such as well systems, reservoirs, buildings, etc., being grouped under one division; the design of mechanical equipment being a separate division, as is also the design of the filtration plant for the Croton supply, the construction of which was authorized in 1911.

The general construction work, exclusive of filtration, has been divided into two parts, one division taking charge of the installation of new water mains and their appurtenances, and the other taking charge of miscellaneous structures.

The laboratory is a separate division, as the work done in this division is of a special nature and connected with that of practically all the other divisions.

The subdivision of the various main divisions is shown on Plate No. 3, herein given, and in general each division has its executive force, and such additional subdivisions as will expedite the work and avoid the placing on any man of a larger amount of work and responsibility than can be reasonably carried.

Under operation and maintenance, the caring for the real estate, and recording of the same, has been made a separate division as the bureau

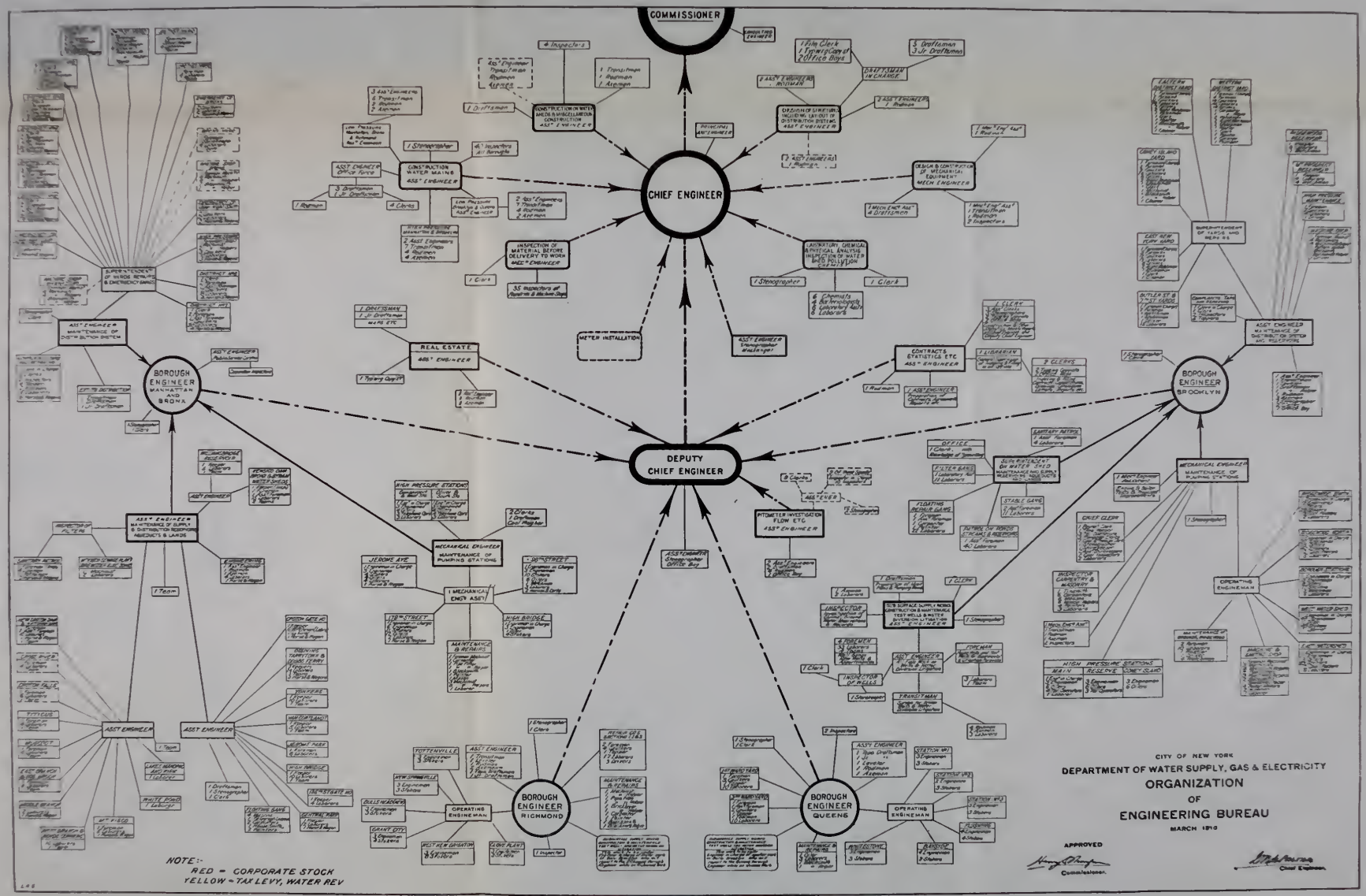
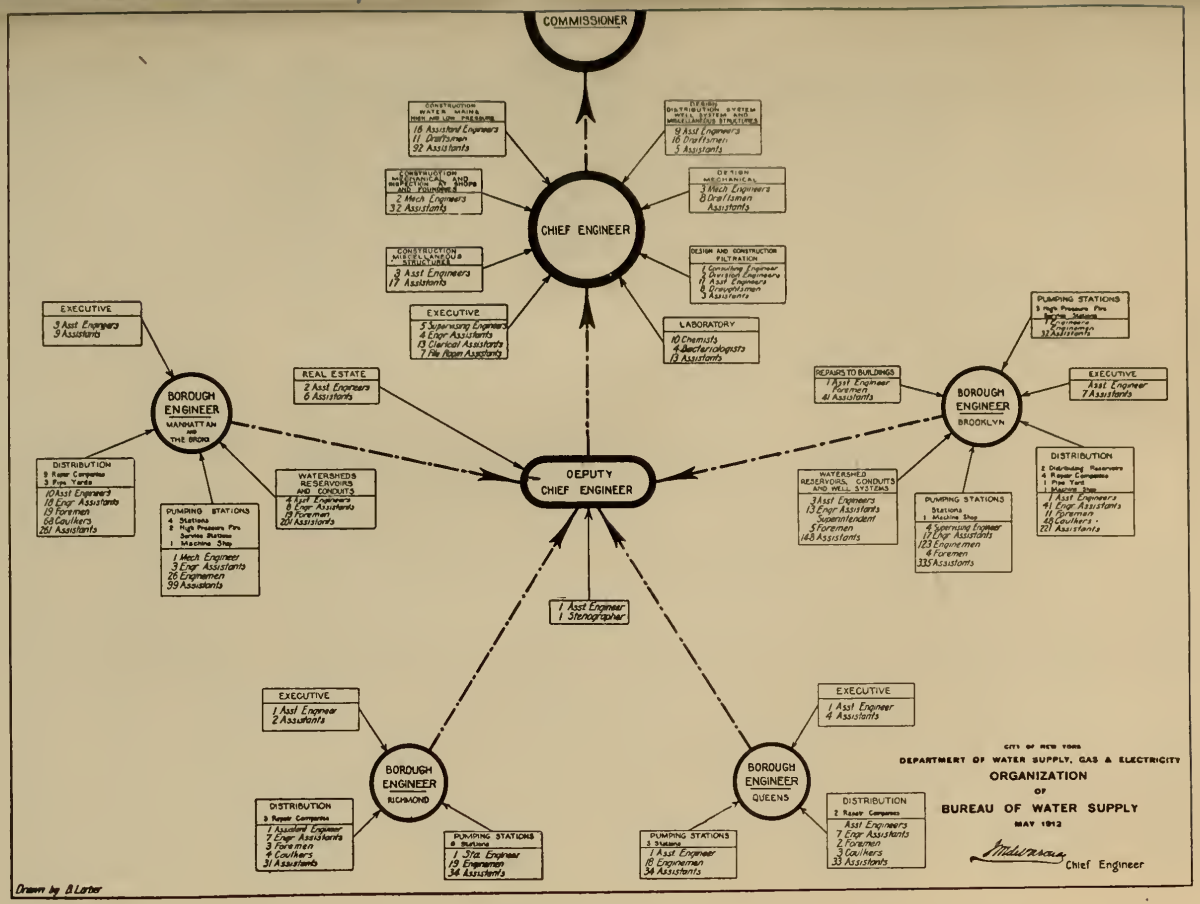


PLATE III. ORGANIZATION ADOPTED



PRESENT ORGANIZATION

of water supply has under its jurisdiction about 27,517 acres, which are scattered throughout the various boroughs, along the conduit lines and in the watersheds.

As the sources of supply for the five boroughs are separate, with the exception of the boroughs of Manhattan and the Bronx, and as the different boroughs are under the administrative control of separate deputy commissioners, the work of operation and maintenance is divided among four borough engineers, the boroughs of Manhattan and the Bronx being placed under one engineer. Each borough engineer has his executive force and separate divisions in charge of pumping stations and distribution. In Richmond and Queens there is no division in charge of watersheds, as driven wells form the only source of supply. For Manhattan and the Bronx and Brooklyn, a watershed division is provided to take care of the watershed, reservoirs, conduits, wells and other works connected therewith. The work on the watersheds is subdivided in accordance with the requirements of the service in Manhattan and the Bronx, the general subdivisions being executive, reservoirs, aqueducts (including distribution reservoirs) and sanitation. In Brooklyn, owing to the character of the watershed development, the subdivisions are executive, reservoirs and aqueducts, driven wells and water diversion litigation. In Manhattan and the Bronx the pumping station work has one executive head, who has control of the high pressure fire service stations as well as the stations pumping the domestic supply. In Brooklyn, the high pressure fire service stations are separated from the other stations on account of local conditions and of the large number of stations connected with the domestic service. In Richmond and Queens the organization for the pumping stations is similar to that in the other boroughs, but a less extensive organization is required, owing to the comparatively small amount of water pumped in the former boroughs.

In all boroughs the distribution system is subdivided into districts, with a repair company in charge of each, separate companies being assigned to the high pressure fire service systems. The number, location and size of these companies is dependent upon local conditions and the extent of territory assigned. For the boroughs of Manhattan and the Bronx and Brooklyn, superintendents of repairs to distribution systems have control of the repair companies, and they, in turn, report to the assistant engineer in charge of distribution. For Richmond and Queens, the assistant engineer takes direct charge of the repair companies.

FORCE AND SALARY ACCOUNT

The following table shows the force employed in the bureau of water supply and salaries paid:

Schedule of employees in engineering bureau, December 31, 1911

POSITION	ADMINISTRATION	DESIGN AND CONSTRUCTION	MAINTENANCE AND OPERATION				1911 TOTAL	1910 TOTAL
			Manhattan and Bronx	Brooklyn	Queens	Richmond		
Chief engineer	1						1	1
Deputy chief engineer	1						1	1
Consulting engineer	1						1	2
Principal assistant engineer								1
Division engineer		2	2				4	2
Assistant engineer	8	37	18	7	2	2	74	56
Mechanical engineer		4	1	3			8	8
Engineer assistant, transitman, rodman, etc.	5	49	16	19	3	3	95	103
Draftsman		30	8	5	3	3	49	48
Chemis			8	1			9	7
Bacteriologist			3				3	4
Laboratory assistant			5				5	7
Superintendent			1				1	5
Clerk, messenger and attendant	21	6	14	11	1	1	54	50
Stenographer and copyist	7	4	4	5	2	2	24	24
Telephone operator			7	11			18	18
Inspector	3	77	5	16	2		103	142
Engineman			27	145	17	20	209	213
Stoker and fireman	1		31	167	20	21	240	264
Oiler			30	57	1		88	88
Foreman and assistant	1		56	39	4	4	104	120
Machinist, steamfitter, etc.			25	52	4	3	84	94
Caulker, tapper, etc	2		77	53	6	8	146	158
Mason, bricklayer, etc.		1	6	16	1	3	27	24
Carpenter, painter, etc.			6	18	1	2	27	34
Driver, hostler, etc.	1	1	1	33		3	39	46
Well-driver and assistant				5			5	12
Laborer		2	315	377	28	43	765	872
Horses, wagons and trucks			84	3			87	89
Total	52	213	750	1043	95	118	2271[1]	2493

Total salaries for 1911	$2,562,532
Total salaries for 1910	2,703,000

[1] Employees in filtration division included in above.

The following table giving the work under the chief engineer in 1902, and the work under his charge in 1912, shows the magnitude of the development during these ten years:

ITEMS FOR COMPARISON	IN 1902 WHEN CHIEF ENGINEER WAS IN CHARGE OF WATER SUPPLY SYSTEM OF MANHATTAN, BRONX AND RICHMOND BOROUGHS	IN 1912 WHEN CHIEF ENGINEER WAS IN CHARGE OF WATER SYSTEM OF MANHATTAN, BRONX, BROOKLYN, QUEENS AND RICHMOND BOROUGHS	INCREASE IN 1912
			per cent
Number of men reporting to chief engineer	750	2270	200
Annual payroll	$510,000	$2,563,000	400
Approximate amount of new construction work during year	$1,200,000	$7,500,000	525
Aqueduct commission work	None	Completion of Croton Falls Reservoir and improvements and alterations Croton system.	
Filtration	None	Design and construction of filtration plant for Croton system, which will be the largest in the world and cost about $8,000,000. Also operation of 3 small plants in other boroughs.	
Revenue from sale of water	$6,000,000	(Receipts for year 1911) $13,300,000	120
Average daily consumption (municipal)	282 million gallons daily.	461 million gallons daily. Water waste work reduced average daily consumption for year 1911 by 35 million gallons.	63
Estimated population supplied	2,230,000	4,631,000	108
Number of pumping stations	4	49	1125
Amount of water pumped	20,100 million gallons during year 1902	145,335 million gallons during year 1911	625
Miles of distribution mains in place	900	2650	195
Miles of distribution mains laid during year	16	81	405
Number of distribution hydrants set during year	310	4580	1380
Number of distribution valves set during year	175	5000	2775
High pressure pumping stations	None	5	
Miles of high pressure mains in place	None	134	

The high pressure fire service system in Manhattan and Brooklyn has been planned, installed and operated under direction of the chief engineer of the bureau of water supply. This system, which has been universally successful since its installation, is the largest of its kind in the world, and protects an area of 4800 acres, within which the value of building and contents amounts to about $2,000,000,000. For the extension of this system, about $1,000,000 is expended annually. The system has resulted in a reduction in fire insurance premiums of about $1,000,000 annually.

Since the new organization was put into effect the aqueduct commission, which formerly controlled the construction of new works in the Croton watershed, has been consolidated with the department of water supply, gas and electricity. This did not necessitate any material change in organization, separate construction divisions being formed temporarily from the aqueduct commission force to complete the work under way at the time of abolishment of said commission.

Deputy commissioners and borough engineers have been kept informed of the work done in the central office through regular progress reports furnished to them by the design and construction divisions, and good progress has been made in standardizing methods and materials used in all boroughs, these questions being discussed at monthly meetings of borough engineers held in the chief engineer's office and meetings of division heads and borough engineers held every three months.

The experience of the last two years has shown that in a system with such various sources of supply geographical conditions, and purely local interests, as ours, a central organization, with only that measure of control necessary to secure uniformity of design, construction, maintenance and operation, is satisfactory both to the administrative and engineering offices, and economical to the taxpayers, and the plan hereinbefore outlined has certainly proved advantageous and well adapted to the conditions existing in New York City. Its practical results may thus be summarized, i.e., the work has been carried on far more economically and expeditiously than under any previous organization; the total force employed has been materially reduced, with an annual saving for salaries and wages of over $350,000 in 1910, as compared with the latter part of 1909, after making allowances for men who were employed in 1910 on special water waste investigations, and for the work of the aqueduct commission, neither of which had been carried on during 1909 by the department; new works that had been proposed prior to 1910 at a cost of about $1,800,000 and for which a large portion of the money had already been appropriated, having been found on examination either unnecessary or unsuited for the purpose, were either entirely omitted or replaced by works involving a much lower cost, the city thereby saving an investment of about $1,500,000, and the estimated annual charges through the elimination of unnecessary and uneconomical extension of the system were also reduced by about $200,000.

While the problem to be solved in most cities will not probably be as complex as that confronting us in New York, perhaps the recital

of our experience may be of interest and some value to the engineers in charge of water works of other municipalities.

DISCUSSION

Mr. Henry B. Machen: New York City is about to start work on the filtration of the Croton water supply, amounting to about 300,000,000 gallons daily, and in order that there should be no question as to the plans prepared by the department engineers, a board of five consulting engineers was convened during the past week to pass upon the methods and plans proposed. It is with great pleasure the speaker is able to state that all of the five consulting engineers who are on this board are members of this association.

THE PHILOSOPHY OF PURCHASING SUPPLIES[1]

By Elihu Cunyngham Church

About ten months ago I was directed to reorganize the bureau of supplies for the water department of New York City, and in carrying out the work I attempted to formulate the principles governing the problem. Briefly stated they are: *get the right materials in correct quantities at the lowest price.*

This involves much more than the mere filling of such requisitions as are sent in; the lowest price being assumed to have been secured because the bidding was competitive. Such procedure is merely doing a commission house business. When a requisition is filled according to its terms there is no assurance that the goods called for are those best suited for the purpose for which they are to be used, that the quantities called for are reasonable, or, finally, that the articles ordered are so specified that standard prices can be obtained.

GETTING THE RIGHT MATERIALS

Taking up these matters in detail it is found that many requisitions fail to describe properly the quality of the material needed. There is a tendency to order the highest grade obtainable when the goods are not to be paid for by the man doing the ordering; this is especially true as men seem to feel that it relieves them from responsibility for any possible failure of the articles when in service. It is an expensive habit, and except in rare cases requisitions should be filled with articles of the standard commercial grades.

GETTING THE RIGHT QUANTITIES

Requisitions as received must also be carefully considered to ascertain if the quantities called for are proper; for, unless there is an inventory of material on hand, one may easily purchase supplies of which there are plenty in stock. I found that new orders are often based

[1] A lecture delivered before the thirty-second annual convention of the American Water Works Association by Elihu Cunyngham Church, C.E., A. M. Secretary of the Department of Water Supply, Gas and Electricity, New York City, and acting chief of the Bureau of Supplies.

on the orders of previous years irrespective of whether materials so ordered were used and without considering that conditions and requirements have changed in the meanwhile. To this end an inventory of the property of the department is being taken and whenever possible requisitions are filled from stock on hand.

STORAGE AND CARE OF SUPPLIES

The storage and use of all goods should also receive the careful scrutiny of the bureau of supplies, for it is inconsistent to keep accounts of money with great accuracy, and then when the money is invested in stores pay no attention to whether they are used or wasted. Improper storage often results in excessive depreciation. Supplies should be issued in rotation; for when stores are issued in the order in which they are received no old material is left on the back of the shelf to deteriorate and subsequently be thrown out. To carry these ideas into effect storehouses are being fitted up at central points, and a number of specially trained men have been installed as storekeepers.

CONSUMABLE AND NON-CONSUMABLE SUPPLIES COMPARED

I have also divided all supplies into two classes, consumable and non-consumable. Fuel, oil, waste and lumber are examples of the first class, whereas tools, implements, rubber boots, etc., belong in the second group. As soon as possible it will be arranged that none of the non-consumable supplies will be issued till those they are to replace have been turned in. Thus a man cannot procure a new tool till he has returned the old one and shown that it was worn out. It is expected that this will safeguard much departmental property and prevent its being used for personal purposes, sold for profit, or so carelessly looked out for that it is either lost or stolen.

SPECIFICATIONS

The problem of obtaining the "right material" brings the question of specifications to the front. Multiplicity of styles and types is a disadvantage, and simplification is greatly to be desired and sought after. To this end investigations and tests are now being made to determine and establish the standards of quality to be met by the various materials purchased. I have had a list prepared containing the items in current demand and they are being considered, one by

one, with regard to their nature, composition, wearing power, keeping qualities, cost and the conditions under which they are to be used in the department. The result desired is to get goods which will give satisfaction when used.

One way of purchasing goods would be to take articles, put them in use and try them out. If they gave satisfaction pay for them. If they did not, reject them and return them to the maker. Even in this case it would be necessary to state what performance would be regarded as meeting requirements. This is not practical. Men want their money upon the delivery of their wares. The purpose of a specification is therefore not alone to set up a standard regarding the kind, size and excellence of the product desired, but it is to enable the department to say in advance with a fair degree of certainty whether goods will probably render satisfactory service.

SPECIFICATIONS SHOULD BE DEFINITE

Nothing should be left to the imagination in the writing of specifications. If a man knows what he wants let him describe it in clear-cut unmistakable language. This takes time but it prevents subsequent misunderstanding accompanied by probable hard feeling and possible litigation.

Adjectives and adverbs have no place in a specification. To say that work must be done "properly" or "suitably" or in a "workmanlike manner" does not really mean anything because what one man will consider "proper" or "suitable" another holds to be quite the contrary. The phrase that goods must be delivered or work done "to the satisfaction of the engineer or inspector" has caused many a contractor to bid high in self defense. It contains possibility of unfairness and graft and should not be allowed.

HOW DEFINITE REQUIREMENTS AFFECT PRICES

It is a noticeable fact that where specifications are indefinite the difference between the lowest and the highest bids is very great, but where the requirements to be met are clear and precise, all the prices are about the same.

SPECIFYING PROCEDURE VS. CALLING FOR RESULTS

Another common fault is to describe in detail the particular methods to be followed in doing a piece of work and then require a warranty as to the result. One should either state in detail the way

the work is to be done and then abide by the result, or specify what is wanted and then let the contractor use his own judgment and ingenuity concerning the best way to bring it about.

GETTING LOW PRICES—LARGE COMPETITION

In order to obtain low prices a number of things are necessary. First it is essential to have as much competition as possible. To bring this about lists have been prepared giving the names of the firms making the various classes of goods, and then we notify them when we are in the market.

BIDDING FOR DIFFERENT CLASSIFICATIONS SEPARATELY

Supply contracts are now so drawn that goods in different groups or divisions, as determined by manufacturing specialization or trade usage, may be bid on separately; for if orders are drawn to contain goods of different classifications the bidders will be "middle men" and "commission merchants," not the makers of the wares nor the regular dealers in the various subdivisions in which supplies are customarily bought and sold.

These "middle men," besides adding their profits to the manufacturer's price, thus increasing the cost of the article, are as a rule irresponsible parties with whom it is often unsatisfactory to do business.

ADVANTAGE OF BUYING LARGE QUANTITIES AT ONE TIME

In order to interest the manufacturers and get them to bid it is necessary to purchase fairly large quantities at a time. To do this the department now buys its supplies every three months and these new quarterly contracts contain sufficient goods in each class to enable the makers to quote wholesale prices.

EMERGENCY SUPPLIES

The principal exception is in the purchase of emergency supplies, and these are obtained when required. The value of placing small orders for hardware and similar supplies as needed from time to time is recognized. This obviates the necessity of keeping large sums of money invested in seldom used materials in order to have a complete stock in the store-rooms. Unnecessary or excessive local reserves of stock will be prevented in future by careful records now being taken to show the regular demands for materials at the various store rooms.

REDUCING DELIVERY CHARGES

Another advantage of quarterly contracts is that where goods are bought in quantities all to be delivered to some central storehouse the proportion of the cost chargeable to delivery becomes very small.

PURCHASING STANDARD MATERIALS

As pointed out an effort has been made to attract manufacturers by writing specifications that can be filled by standard goods, and by making the requirements so clear and definite that there is little or no chance for misunderstanding.

PROMPTNESS IN AWARDING CONTRACTS

Every effort is made to reduce the time which it takes to canvass bids, notify the low bidders and award the contracts, for delay in this respect might cause loss and inconvenience to bidders due to possible changes in prices and market conditions in the interval.

SYSTEMATIC METHODS MEAN QUICK PAYMENT OF BILLS

The new methods have so simplified matters that on the average the time required after the delivery of supplies to inspect them, audit the bills and forward the bills to the comptroller for payment has been reduced from many weeks to less than eight days.

NECESSITY FOR BUSINESS ADMINISTRATION OF BUREAU OF SUPPLIES

In fact it is fully realized that in order to get low prices there must be fair competition between responsible manufacturers who find it to their interest to do business with the department; all of which means that the bureau of supplies must be handled as a cleancut business proposition.

AIM OF THE ORGANIZATION OF THE BUREAU

In the bureau of supplies itself conditions and operations are being standardized so that nothing will be done in a haphazard manner or left to chance. The work of the present aims to secure the economy of the future by so systematizing and simplifying the work that it can be done by the fewest possible number of employees at the least cost.

DISCUSSION

Mr. Harrington Emerson: Before starting on his own talk the speaker wishes to express his very great gratification at the preceding paper. Rarely has he heard a paper that pleased him more. It is the first he has heard at this convention, the others may have been of equal excellence but he was not fortunate enough to hear them.

The speaker would like to add one word to what his predecessor has said. The finest line of specifications he has found anywhere are those of the United States navy department. Of course the navy has to buy everything under the sun, and has had very long experience, so it happens to be the most efficient thing that the speaker knows of on earth, and its specifications come also under that heading as far as his experience goes. He thinks any one of you in search of modern, definite and ample specifications can gain a great deal by calling upon the navy to furnish you some of its blanks.

Mr. Elihu Cunyngham Church: The speaker desires to express his appreciation to Mr. Emerson of what he has said of his paper. He would also like to say that Mr. Emerson's writings have been the inspiration that started him along these lines.

THE PRINCIPLES OF EFFICIENCY APPLIED TO WATER WORKS

By Harrington Emerson

A principle is an eternal truth, not a man-made device. All action and phenomena can be analyzed to a few principles.

Our lives are like the figures in a kaleidoscope. Never does the same figure appear twice. There are untold millions of variations, but if we take the instrument apart we find only a few never-changing bits of colored glass, and a single underlying principle of reflection.

There is one underlying principle of righteousness. There are a few ideals combined into a philosophy of life. Each ideal has its own principles and each principle its own application, so that in the end we have infinite variety proceeding out of elementary simplicity.

Therefore when we examine any business whatever, we do not care about details, about methods, about devices. They will easily be right if the fundamentals are right, and they cannot be right, however perfect in themselves, if the fundamentals are missing.

General principles fall into two classes, the altruistic principles and the practical principles. The practical principles are those underlying scientific management; the altruistic principles are those underlying industrial righteousness. The highest efficiency depends on both righteousness and management.

The wreck of the *Titanic* was due to a disregard of the altruistic principles. The ideal of safety was disregarded—or the steamship would not have been where ice was; common sense was not practiced —or speed would have been lessened, the lookout doubled and search lights been used; competent counsel was ignored—for wireless warnings of the location and extent of the ice were received from three different steamers. The fair deal was forgotten, the passengers supposing luxury to be merely the polish on the pure gold of reliability; discipline was lost—or the boats would not have gone off half filled; there was no efficiency reward offered for special care.

It is considered smart to speak flippantly of Noah and his Ark, but Noah, knowing little of either science or organization, observed all the ethical principles and he got there. Safety was his ideal, not luxury or speed. He accepted advice and acted promptly on it; he gave the fair deal to others, for he warned all and saved those who

believed, he maintained discipline and by a special offering showed his gratitude.

Assuming that the writer knows nothing about the design, management or operation of water works, he will apply to this business the principles of efficiency, both altruistic and practical, and exhort you each in his own position to utilize this new method of analysis.

The altruistic principles of efficiency are six: (1) Ideals; (2) Common Sense and Judgment; (3) Competent Counsel; (4) Discipline; (5) The Fair Deal; (6) Efficiency Reward.

The practical principles are also six: (7) Records—Immediate, Reliable and Adequate; (8) Planning and Despatching; (9) Standards; (10) Standardized Conditions; (11) Standardized Operations; (12) Written Standard Practice Instructions.

Ideals. Since the ideals of a business necessarily affect its entire organization, its employees, its relations to other corporations and to individuals, it is of tremendous value that they be definitely determined, and fully appreciated. The McAdoo tunnel system, under the Hudson, at New York, has adopted as one of its ideals, "The Public be Pleased." It has dinned this into the ears of its organization until every guard, conductor and platform man is a living embodiment of it. The service is carefully adjusted to the needs of the patrons. The public is quickly informed of the reasons and probable duration of adverse conditions if through accident its comfort will temporarily be interfered with. As a result the company's patronage has grown enormously, and—wonderful to relate—when its rates were raised six months ago there was little or no protest.

For a water works system its ideal as to the public is equally as important as for a railroad system.

But this is only one ideal. There are others for a water works.

The main or chief ideal for a water works system, since life itself is involved, is safety, the same as for the *Titanic*, but for the water works system meaning pure water—water not necessarily limpid, but free from disease germs. The wonderful spread of filtration, of the application of hypochlorite, of the agitation against the pollution of potable supplies—all indicate that water works men generally appreciate and are endeavoring to attain this ideal. It cannot, however, be too often or too strongly emphasized.

Other ideals are abundance, continuity of service, comfort, economy.

Abundance bears on the social progress of the community and on fire protection. The careful investigations as to new sources of supply constantly going on indicate that this ideal is clearly fixed in your

minds. Nevertheless, the danger of shortage at New York City, not an impossibility had not the Catskill project been pushed to conclusion with such admirable rapidity, indicates that either the engineers or the politicians are not letter-perfect as to this ideal.

In speaking of "abundance," it is not inopportune just to mention the subject of water-waste. It is so much dinned into your ears, that the writer will not stop to "rub it in." Abundance, both to the purveyors of water and the consumers, is considered a license to waste. Efficient management cannot accept this construction, for its object is the elimination of all wastes whether of material things or time of men and equipment.

If as to this one point alone, the emphasis on ideals should jar your consciences, the writer would consider his time well spent. If the manager of a gas plant, or an electric light plant, should be as indifferent to wastes as water works managers have been, his board of directors would make short shrift of him.

Continuity of service has bearing on both health and fire protection.

Comfort is a subsidiary ideal. A water warm, colored, turbid and strong tasting, even though safe, abundant and continuously supplied can hardly be called perfect. A cool, clear, tasteless supply is therefore wanted.

Another ideal is economy, and this ideal is all the more important because economy may have to be waived in favor of purity, of abundance, of clarity, of non-corrosiveness. The more reason, of course, for not adding to cost by non-essentials. The crying error of the present age is inefficiency, and as a means of inculcating efficiency, of plainly measuring waste, the writer believes in metered light and metered water. He once lived in a house where the water was metered and the landlady did make the taking of baths disagreeable, but the education she got from dripping faucets as to cost of water had so reacted on all her habits that she was successfully buying a $10,000 house.

Common Sense. Common sense does not stand by itself, but controls the application of the other principles to a particular business. As to water works, for example, common sense is necessary to reconcile the different ideals—an abundant, but turbid supply, as against a smaller but limpid one—or an abundant but expensive supply, as against a smaller but cheaper one. In this connection, the ideal of safety—purity—seems, to the layman at least, to be inviolable, not subject to compromise in order more nearly to attain other ideals.

Common sense again must be used in applying all plant laws, in fitting the rules (or suspending them) to extraordinary conditions, in altering them as better practice develops, in recognizing the fetters which hide-bound "system" is apt to place on a plant and so lower its efficiency.

Common sense generally means a compromise, but the compromise should be deliberate.

Competent Counsel should be sought from all sources. The time to secure it is before money is spent, not afterwards. There is hardly one of you who cannot tell of some serious blunder in selection of source of supply, in choice of power and pumping equipment, in arrangement of plant, in lay-out and construction of service mains, that would have been avoided had competent counsel been secured. As to additional supplies for large cities, filtration problems, sterilization, water works men have shown commendable observance of this principle, but have the smaller cities been equally wise in selecting new supplies, have large and small plants consulted competent advisers as to fuel, pumping equipment, operation of stations, investigation of waste, figuring of costs and the troublesome problem of depreciation and amortization?

Counsel is usually not to advise us what to do, but to advise us what not to do. In life as in chess there is each time only one right move, but a score of bad moves possible. Again if a road forks twenty times, the route from one point to another may be absolutely plain and certain even on an inky night to an old horse, but to the man who has not been over it there is only one chance in twenty of making the trip successfully the first time.

Discipline. To those of you connected with privately owned plants the necessity for discipline within your organizations is not only patent but evident from actual practice. Many of you connected with municipal plants, alas! know the necessity of it but seldom or never meet discipline face to face. It is conspicuous by its absence. When through political power the head of a water department cannot discipline his chief engineer, when the latter has the whip hand, how can coöperation, economy, efficiency be expected? When experts place in the hands of authorities proof of inefficiency, but politics, the lack of discipline, results in the reports finding a speedy path to the waste basket, who can expect low operating costs?

Until our municipal politics undergoes a marked change, until professional men, such as water works engineers, observe the ethics of their professions instead of playing into the hands of politicians,

seeking their strength there rather than in their ability and records, an efficient municipal system cannot be generally expected.

Fair Deal. The fair deal is both subjective and objective—subjective in so far as it applies to the relation of the management with the men—objective as regards the relation of the company or department with the consumers. The former is, with efficiency reward, one of the prime bases for that coöperation which alone assures permanent high efficiency. The latter is the only hope (and even that may not avail) for the public service corporation against the unfortunate feeling which the abuses of some utility corporations have brought upon all in that class. That the fair deal to the public, favoritism to none, is effective is amply proved by the history of the McAdoo Company, above cited, and, though the writer does not know of instances, such must also be true of many well-managed water works plants.

As to the subjective part it should be remembered that kindness, affection, good will, generosity, sympathy, do not constitute the fair deal. The fair deal as practiced at West Point is very much better than the fair deal extended by his mother to Harry Thaw.

Furthermore a metered water supply is distinctly the fair deal to company and consumer while unmetered waste is not.

Efficiency Reward. This demands that each man shall be compensated in proportion to his efficiency—that men shall cease to be parasites, that each shall stand for himself and take his remuneration in accordance with the excellence of his service to his employer. This does not necessarily exclude collective bargaining as to a minimum wage. It demands further that men be given a share in the savings which result from their greater efficiency. Without the fair deal and efficiency reward, high efficiency cannot permanently be maintained.

Bonus and differential piece-rate systems are two particular methods of giving this efficiency reward.

We now come to the practical principles:

Records—Reliable, Immediate and Adequate. It is common experience that it is not very difficult to get some sort of records kept reliably; that it is more difficult, however, to get reliable records that contain *all* the information desired, and that it is tremendously more difficult to get reliable and adequate records immediately. The immediate record, which tells you costs, the day after the occurrence, is rare, but it is obtainable under average conditions and such is the record that efficient managers should insist upon. A record of yes-

terday's operations received today can be used with telling effect upon those responsible for high costs; its force will be less a week hence and will be entirely lost after a month.

The principle of records applies not alone to costs, but also to lay-out of plant and distribution system. The hoary instance of an old foreman carrying the valve locations, the size and history of the mains under his hat is too old to warrant elaboration.

Planning and Despatching. Planning and despatching mean less to a water works than to a factory. In a factory, they mean that each order is analyzed into its parts, the time of entry and exit of each part as to each department set, and a systematic record, or despatching system, maintained to see that the plan is adhered to.

Planning and despatching, however, would apply to the doing of repair work, overhauling of machinery, washing of boilers, and similar operations in the pumping station, and to all of the work involved in the laying of mains, tearing up streets for house connections, making of these connections and restoration of pavement. As tearing up of streets for house connections intelligent planning might eliminate much of it by providing that this work be done in connection with gas or electric light work, or that arrangement be made to carry service pipes inside the curb line when laying the mains.

When such work must be done, however, a careful grouping of the jobs, proper assignments of gangs and intelligent supervision, would result in eliminating much lost time in going from one job to the other. The remarkable results accomplished in catch-basin cleaning in New York, as described in *The Engineering Record* of December 9, 1911, is well worthy of your attention. The work, while apparently dissimiliar to yours, has many points in common. Here, without overexertion on the part of the men, the work per man was increased fourfold.

Where you do your own construction work the opportunity in this connection is golden.

Standards. Standards are the keystone of efficient management. By them efficiency is measured—for *efficiency is defined as to relation between actual achievement and an equitable standard.* How can you buy pipe unless you have standard units—the inch for the diameter, the foot for length? How can you pay for it unless you have standard units—the pound for weight, the dollar for value? How can you measure the value of your coal unless you have standard units—the pound for weight, the B.t.u. for calorific value?

How then can you determine the efficiency of your pumping cost unless you have a standard—a unit—which we call 100 per cent efficiency? How can you know the efficiency of your filtration costs unless you have a standard? How can you judge of your pipe laying unless you have a standard—the number of feet per day per man (varying it of course for size of pipe, depth of trench, men in gang)? How can you know the efficiency of your filtration beds unless you have a standard—so many millions of gallons per acre per day under your particular conditions of kind of bed and water?

This list can be multiplied indefinitely.

The efficiency engineer contends that if not impossible there should be for each machine or piece of equipment, for each process or operation, for each individual, each foreman, each superintendent, a standard—a fair, feasible standard—for judging.

These standards should not be past records. Past records show what *has* been done; past records do not show what *should* be done. The standards cannot be taken from other plants and applied to yours, unless conditions are exactly duplicated, and that seldom occurs.

Moreover having the standards, efficiency records based on them are necessary. Standards are established only to help raise efficiency. Otherwise why establish them?

Having efficiency records—use them. Tie up with efficiencies, whenever possible, an efficiency reward, thus creating an incentive for the men to get better results. Pay a bonus to foremen and superintendents on the average efficiency of the men under them. Then it is to their financial interest to teach their men the more efficient ways that have been devised, or if the men are unsuited to the work to have them transferred to other work for which they are suited and on which they can attain high efficiencies.

Under the head of standards comes the question of supplies—standards for all material purchased. This matter I pass over, since Mr. Elihu C. Church, of New York, who is well qualified, is to present this subject to you.

Standardized Conditions. Antecedent to the establishment of standards must come the standardization of conditions—that is, the improvement of all plant equipment, tools, buildings, and all other conditions, so that equipment and men have everything favorable to maximum output—to standard efficiency. Boilers, pumps, tools, mains, everything must be maintained at the highest excellence if 100 per cent efficiency is to be realized.

Under standardization of conditions would come the metering of all services, since efficient operation demands that we penalize waste in order that by penalizing we may entirely eliminate it. Metering of all services, too, it would seem, should result in segregating to the mains the actual leakage therein occurring, thus removing the unknown factor, particularly where house inspection is lax, of fixture leakage.

Standardized Operations. Having made all conditions favorable to maximum production, the allied step is to standardize operations. We cannot expect 100 per cent from a boiler capable of 100 per cent performance if it is fired by a man whose stoking efficiency is 50 per cent. The operation, stoking, must be standardized, the best method determined and taught the man. Likewise 100 per cent efficiency cannot be secured on a construction job, where all conditions such as width of trench, location of pipe to be laid, quality of lead or joint filler, style of lowering tripod, kind of lead furnace, kind of caulking tool, etc., have been standardized, that is, made and selected favorable to maximum production, unless the operations, the lowering, setting, caulking and backfilling of the pipe have been standardized, and the best methods so determined are applied by the men.

Written Standard Practice Instructions. Having determined the conditions favorable to maximum production, and the quickest and easiest way of performing the operations, having set standards, installed proper records and a planning and despatching system, all these are described in written instructions, which become the codified law of the industry and prevent any man from walking out with the only record (a mental one, to be sure) of vital data under his hat and so crippling the plant.

These principles conscientiously and intelligently applied and then adhered to have never failed to change vague aspiration, haphazard action and almost accidental achievement, into definite aims, regulated action, and astonishing achievement. Many of you doubtless are applying some of these principles, either in their fullness or in part. In so far as you are applying them, will be your appreciation of the advisability of their more extended application.

THE VALUE OF A CONTINUOUS SETTLING BASIN, AND A DISCUSSION OF THE ECONOMIC PRINCIPLES OF DESIGN OF SUCH REINFORCED CONCRETE STRUCTURES

By Alexander Potter

The city of Muskogee, Oklahoma, has under construction a number of improvements to its water supply and sewerage system together with a garbage incinerator plant, with which improvements the author has been identified both as designing and supervising engineer. The water improvements consist of the construction of an intake tower in the Grand River some two thousand feet above its junction with the Arkansas River, a 54-inch concrete lined intake constructed in rock tunnel under the Arkansas River, and 2500 feet long, the installation of additional pumping units, both high and low lift, of a water purification plant, the reinforcement of the water distribution system, and the construction of a six million gallon equalizing reservoir, consisting of a 50 sided polygon whose walls are built entirely above the ground, each side consisting of an Ambursen dam section.

That portion of the water purification plant now under construction is sedimentation assisted by coagulation with ferrous sulphate and lime. Provision is made so that ultimately mechanical filters can be introduced if they should be found necessary. In this article, the settling basin only will be discussed.

DESCRIPTION OF SETTLING BASIN

The new settling basin for the Muskogee water works is a reinforced concrete structure, 212 feet square on the inside (Plate I). When filled to a depth of 18 feet, this basin holds over 6,000,000 gallons of water. A curtain wall of reinforced concrete divides the basin into two compartments. The first or smaller of these compartments, 212 feet long and $52\frac{1}{2}$ feet wide, has the bottom perforated and underdrained. A distributing trough 3 feet 6 inches wide and 5 feet deep extends the entire width of the first compartment. The water enters the first compartment from the distributing trough supported on the counterforts through a series of 8-inch round openings

spaced two in each panel formed by the counterforts. A 4-inch concrete baffle or stilling wall in front of the distributing trough extends the entire length of the basin. The water passes through the first compartment over the curtain wall into the larger compartment. Balanced valves in the bottom of the curtain wall equalize the pressure on the wall during filling. A collecting channel of the same size as the distributing channel is located at the far end of the basin, extending the entire width of the basin. The water enters the collecting channel through a series of 2-foot weirs located one in each panel. The basin is designed to operate continuously.

ADVANTAGES OF CONTINUOUS SETTLING

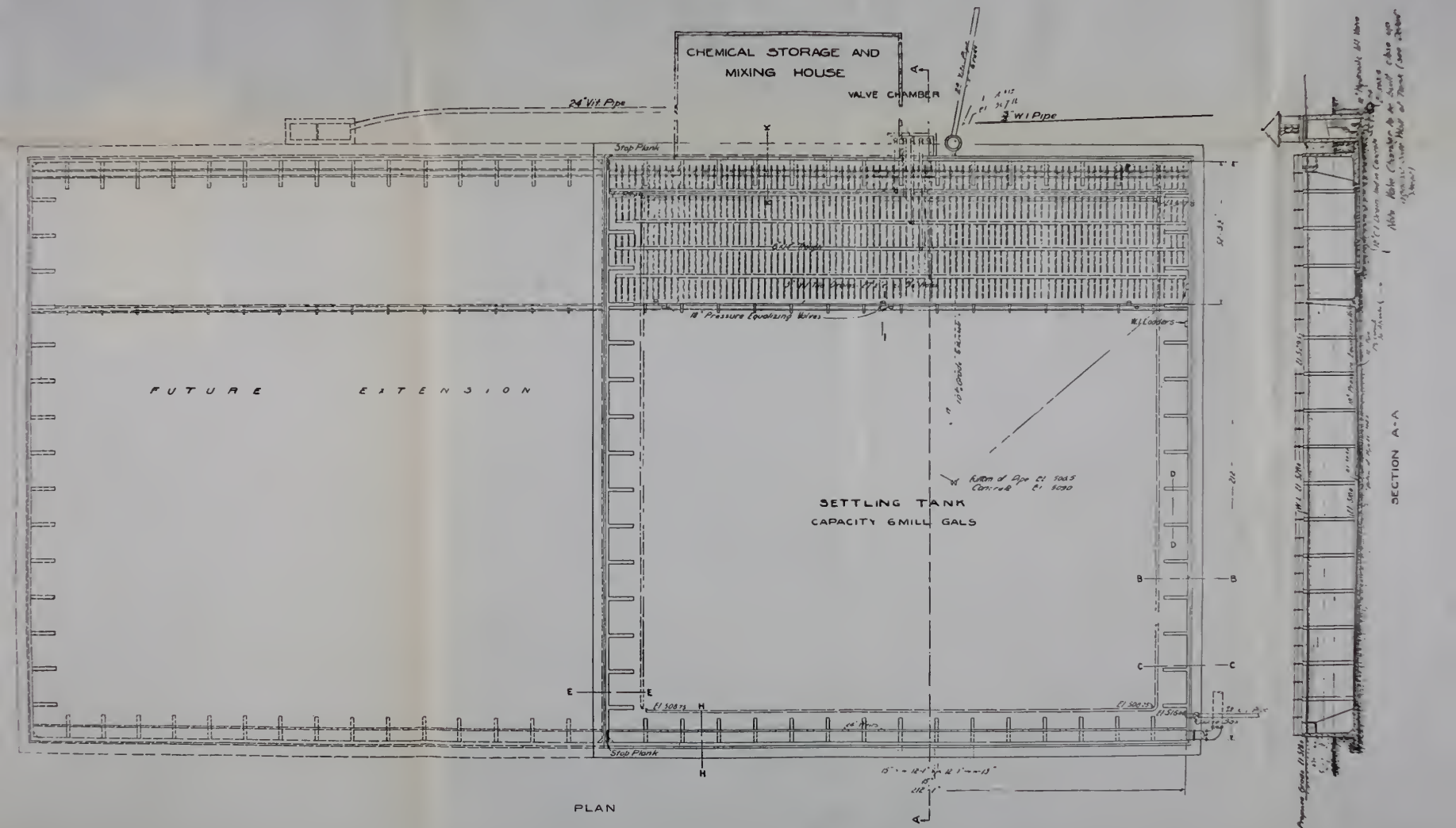
A settling basin operating continuously possesses a number of advantages over a basin which is operated intermittently. There is first a considerable saving in the size of the settling basin when the settling is carried on continuously. This saving may amount to as much as fifty per cent over an intermittent installation in which two basins are used, decreasing, of course, somewhat with the number of basins. When a settling basin is operated continuously, the capacity of the basin, except for the sludge displacement, is always available, which is not the case with the intermittent type. There is no reason whatever why in a properly designed basin the settling efficiency should be impaired by the disturbance at the inlets and outlets.

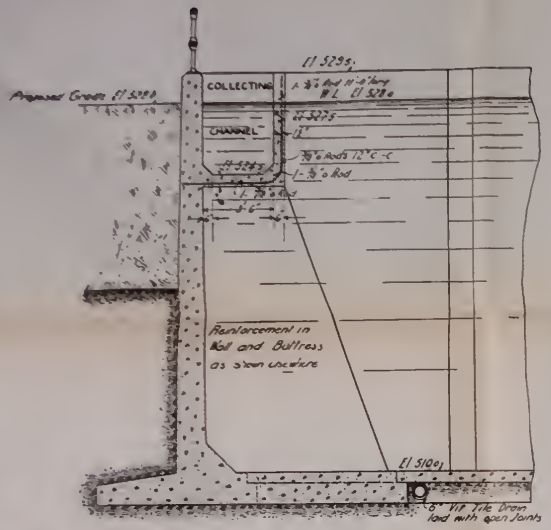
REMOVAL OF SLUDGE

The author wishes to call attention at this point to the method to be used in the Muskogee settling basin for removing the settled sludge from the first or smaller compartment without interfering with the efficient continuous operation of the plant. The small compartment, as is shown in Plates I and II is underdrained. These underdrains consist of 3-inch vitrified pipe drains, each perforated with a hole $\frac{9}{16}$ inch in diameter. The underdrains are laid with Pioneer Asphalt joints, and are arranged in five zones. The collecting channel for each zone is 8 inches deep and 14 inches wide. Each channel is covered with a $27\frac{1}{2}$ inch by 24-inch reinforced concrete slab, 3 inches thick, perforated with two $\frac{1}{2}$-inch holes in the center. A 12-inch cast iron pipe is carried from the collecting channel to the sludge chamber shown in Plate I.

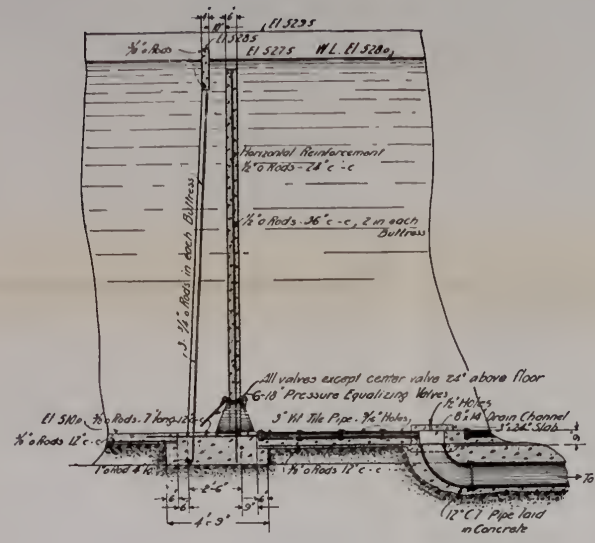
The sludge valves are 12-inch hydraulically operated valves. Each valve controls a zone approximately 212 feet long and $10\frac{1}{2}$ feet

PLATE I

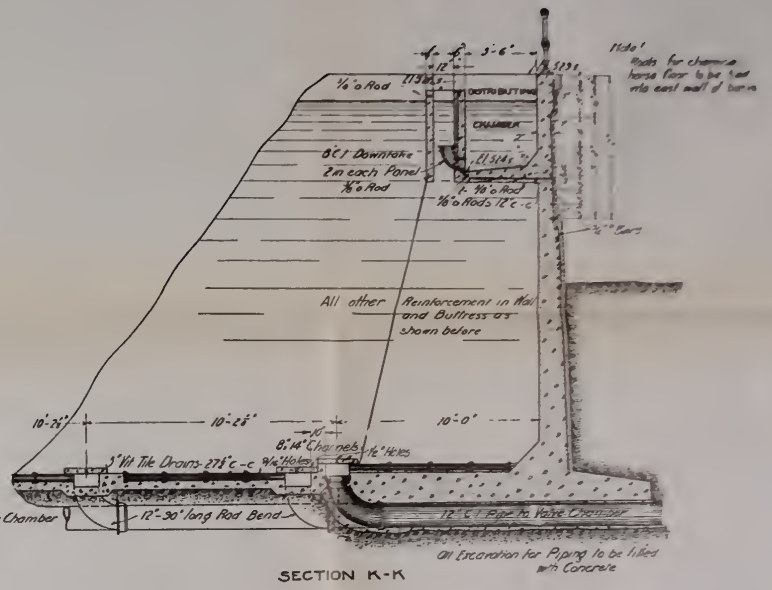

CHEMICAL STORAGE AND
MIXING HOUSE
VALVE CHAMBER
24" Vit Pipe
3" W.I Pipe
Stop Plank
18" Pressure Equalizing Valves
W.I Coolers
FUTURE EXTENSION
SETTLING TANK
CAPACITY 6 MILL GALS
Stop Plank
PLAN
SECTION A-A



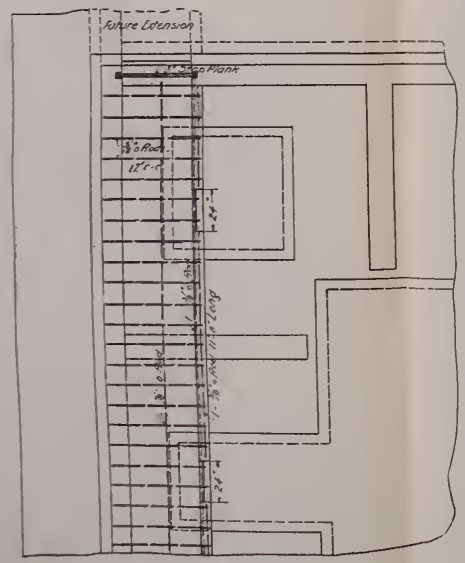
SECTION H-H


El 5295
El 5275 W.L. El 5280
Horizontal Reinforcement
All valves except center valve 24" above floor
6-18" Pressure Equalizing Valves
3" Vit Tile Pipe
Drain Channel
To Valve Chamber
12" C.I. Pipe laid in Concrete

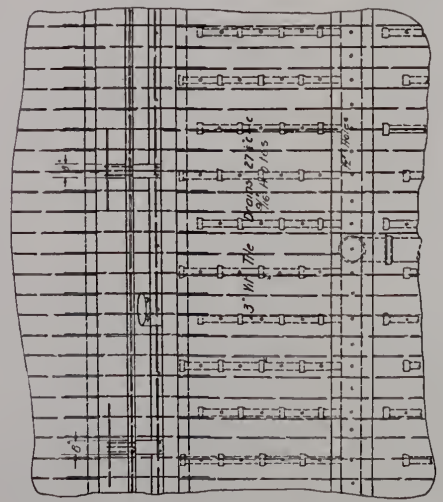
SECTION I-I


Holes for channel horse floor to be set into east wall of barn
8"C.I. Downtake
2 in each Panel
All other Reinforcement in Wall and Buttress as shown before
8"x14" Channels
3" Vit Tile Drains
12" C.I. Pipe to Valve Chamber
All Excavation for Piping to be filled with Concrete

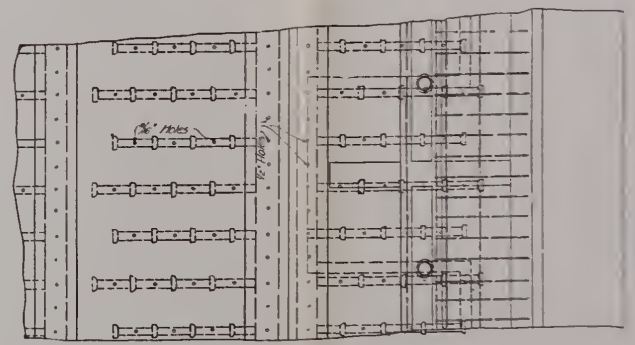
SECTION K-K



PLAN



PLAN



PLAN

wide. In each zone are 315 holes or perforations each $\frac{9}{16}$ inch in diameter, spaced 2 feet on centers in rows $27\frac{1}{2}$ inches apart. In addition there are 180 $\frac{1}{2}$-inch holes in the concrete covers of the main collectors. As the amount of sludge deposit depends principally upon the distance from the distributing trough, the arrangement of the zones, as shown in Plate I, is such that the sludge will be fairly uniformly deposited over the area of any one zone.

OPERATION

The intervals between openings of the valves and the length of time they remain open at the outlet end of the sludge drains will vary with the condition of the raw water. The precipitated solids should not be allowed to accumulate long enough to pack over the openings. The sludge valve should be closed at once when the discharge, which is visible at all times, begins to show up clear. If we could go down and examine the bottom immediately after the sludge is drawn off, we would find a cone-shaped depression in the sludge at each of the perforations. Between the perforations, some of the sludge would be left standing in the form of wedges and pyramids. The angle assumed by the side slopes of the sludge depends somewhat upon its character. and also the frequency with which it is being drawn off. Assuming a side slope of 45 degrees for the sludge, which is considerably steeper than most sludges stand in water, the amount of sludge that is out of reach of the underdrains in this particular case would cover the bottom, if considered uniformly distributed, a depth of 6 inches. This means a decrease in the capacity of the first compartment of approximately 2.8 per cent.

DESIGN OF PERFORATIONS

Great care should be exercised in the design of a system of underdrains such as has been outlined, to insure its successful operation. The underdrains and perforations must be designed so as to give the same amount of suction for all of the perforations or holes in any one zone. Otherwise, clean water will be drawn in at those points where the suction is greatest, and while sludge is still covering a large part of the openings. Such a condition not only leads to a great waste of water, but results sooner or later in the partial clogging of the perforations, and ultimately in the permanent breakdown of the underdrain system. To be efficient, the water must enter the perforations at as high a velocity as it is practicable to obtain. This means that,

especially in a shallow tank, the frictional losses in the underdrains and effluent pipes, and the velocity head at the discharge end, must be kept down as much as possible. In the average plant, the area of each valve should approximate the total area of the perforations tributary to the valves, preferably less, although this proportioning is claimed to be protected by patents. Quick opening valves should also be used for economy. Ample provision should be made to prevent excessive pressures developing in the effluent pipe from water hammer. Valves 8 inches, or smaller, can be readily operated by hand; larger valves should be either hydraulically or electrically operated.

SYSTEMS IN USE

The author has used this system of sludge removal with great success. It is in use in the settling basin of the water purification and softening plant for the city of McKeesport, Pa., put in operation in 1908; and in the settling basin of the municipal water purification plant for the city of Georgetown, Ky., in operation since May, 1911. Both of these plants were designed and constructed by the author, and to the best of his knowledge there has been no breakdown at any time in the underdrain system.

The larger compartment of the settling basin, comprises three quarters of the total capacity of the basin. It has a sloping bottom draining to a sump. A 12-inch cast iron sludge pipe is carried from this sump to a 24-inch vitrified pipe drain located outside of the basin. It is expected that fully 85 per cent of the suspended solids will settle out in the first compartment. For this reason it was considered unnecessary to underdrain the larger compartment. Whenever the sludge reaches a depth of several feet or more in the larger compartment, the operation of the basin will have to be suspended and the basin cleaned. The turbidity of the river water, however, is normally low, and it is not expected that this will happen more than once in several years.

The cost of constructing the underdrain system for the removal of the sludge, is not great when compared with the economy resulting in the cost of operation. By removing the sludge daily, the capacity of the basin is not impaired, as is the case when the deposits are allowed to accumulate. In the former case, the efficiency of the basin is maintained, whereas in the latter the accumulated deposits of settled solids displace more and more of the water content of the basin, often to an extent which seriously impairs its efficiency. The

full capacity of the basin is most sorely needed when the river is turbid, but it is then that so much space is occupied by accumulated solids which cannot be removed because every inch of space is needed to assist in settling. The emptying and cleaning of a basin is a costly operation, especially in winter time, and is to a very great extent avoided, even if only a portion of the basin is properly underdrained.

QUANTITY OF WATER REQUIRED IN CLEANING

The amount of water that passes off with the sludge in the system just described is not excessive. It is estimated that in the Muskogee plant this amount of water will not exceed one-sixth of one per cent of the water treated.

GENERAL DISCUSSION ON REINFORCED CONCRETE

The basin is being constructed of reinforced concrete. The value of reinforced concrete construction for water works purposes is perhaps not so fully appreciated as it should be. The advantages of a reinforced concrete structure over one constructed of plain concrete, together with the resultant economy in the cost of construction, are far greater than the profession has been ready to admit. The structure in question may safely be said to bear out this statement. Our knowledge of reinforced concrete is comparatively recent. It is only in the last decade that we have been able to produce in the field a product whose physical properties are sufficiently uniform and well understood to enable us to construct the wonderful structures now possible. It is but a question of time, and that only a very short one, when reinforced concrete will entirely displace the heavy masonry and plain concrete structures so common in the last decade. For water works purposes, a reinforced concrete structure possesses the same advantages over a structure constructed of masonry or plain concrete, as the modern buildings of structural steel and reinforced concrete possess over the old and now obsolete form of building construction with which most of you are familiar.

REINFORCED CONCRETE VS. PLAIN CONCRETE

Reinforced concrete differs materially in many respects from plain concrete. The physical properties of plain concrete can be best understood by comparing it with one of the natural stones, such as sandstone, which it very closely resembles. Reinforced concrete, on the

other hand, is an entirely different material. Unreinforced, the material is brittle, possesses very little ductility and tensile strength; reinforced, the material is tough, possesses considerable ductility and enormous tensile strength. In many ways, the properties of reinforced concrete are very similar to those of structural steel, and it also is adapted to many of the uses to which structural steel is put.

It is possible to construct a monolith of plain concrete of considerable proportions. However, it is but a question of time when the unequal settlement of the foundation, always present except when the foundation is solid rock, the shrinkage and temperature stresses set up in the mass, destroy the continuity of the structure. On the other hand, it is possible to construct and maintain as such a reinforced concrete monolith of very large proportions.

WATER TIGHTNESS OF THIN SECTIONS

There appears to be some doubt that thin sections of reinforced concrete are suitable for water tight structure. There need be no fear whatever that trouble will occur if the work is carried out as it should be. The water tightness of concrete depends principally upon the amount of cement present, provided the sand and stone or gravel are properly proportioned. Six bags of cement per cubic yard of concrete is ordinarily sufficient to produce a water-tight mixture. This amount, however, should be increased when the hydrostatic head is considerable.

WATERPROOFING NOT ESSENTIAL

The author is opposed to the use of waterproofing ingredients or waterproofing applications. Both increase the cost of the concrete work considerably. It is far better to put the value of the waterproofing materials into the concrete itself by adding more cement. The use of a waterproofing ingredient or application tends to poor construction work, the contractor counting upon the waterproofing to materially help out careless construction.

CAUSES OF LEAKAGE

The author, from his study and experience in the construction of tanks and reservoirs has reached the conclusion that leakage may be due to any one of the following causes:

1. Faulty construction: (a) Lean and porous concrete work, (b) Inexperience and carelessness in carrying out the construction.

2. Faulty design: (a) Weak details at the connections, (b) Excessive secondary stresses at connections, (c) The use of too high unit stresses in steel and concrete.

Faulty construction can be rectified to some extent, but often only at a considerable cost, by waterproofing the structure from the inside. Leaks developing through faulty design are, on the other hand, always difficult to master, and in many cases very little can be done to remedy the unsatisfactory condition of the completed structure. To guard against the production of lean concrete work, the author's specifications provide that all cement used in the work should be paid for separately.

COUNTERFORT OR BUTTRESSES

As 10 feet of the basin is constructed below the original surface of the ground, it was decided to use counterforts instead of buttresses to save excavation. The counterforts are 15 inches thick, spaced 13 feet 4 inches on centers. The side walls of the basin are 12 inches thick on the top, widening out to 18 inches at the bottom. The floor of the basin is 6 inches thick in the larger compartment, and in the smaller and underdrained one 9 inches. The basin, including the floor, is constructed and reinforced as a monolith. No expansion joints whatever are provided. There will, however, be an expansion joint between the present basin and future extension.

The author would like to get the opinion of the members on their experience with extensive monolithic construction, both plain and reinforced, especially with reference to the conditions under which such construction has given more or less trouble.

IMPORTANCE OF STRUCTURAL DETAILS

The success of a reinforced concrete structure of any magnitude depends principally upon the thoroughness with which the various structural details, especially the connections, are worked out. The connections should receive the same careful attention that is given them in structural work.

The author therefore thinks it advisable to dwell at some length upon the design of the structure.

DETAILS OF DESIGN

The Muskogee basin is being constructed of gravel concrete. The gravel is washed river gravel, obtained from the bed of the Arkansas River. Its size is limited to 1 inch in the side walls and counterforts, and to 2 inches in the bottom. The sand is a very coarse river sand, obtained from the same river. It is clean, coarse and sharp, and makes a splendid concrete sand. The concrete is being mixed approximately in the proportion of one part of Portland cement, two parts of sand, four parts of gravel. The mixture is changed slightly from time to time to meet slight changes in the quality of the aggregate.

In the design of the structure, the unit stresses were assumed as follows:

f = The maximum allowable working compression in the concrete in flexure, 650 pounds per square inch.

f' = The maximum allowable tension in the steel, 14,000 pounds per square inch.

v = The maximum intensity of transverse shear in concrete (assuming a uniform distribution of the shear), 50 pounds per square inch.

u = The maximum working adhesion or bond stress between the concrete and deformed bars, 80 pounds per square inch.

e = The ratio of the modulus of elasticity of steel to concrete, 12.

These values are conservative. They limit the percentage of the steel to be used in the structure to 0.83 per cent of the area of the concrete above the steel.

The following equations, with numerical constants, have been developed in accordance with the now universally recognized theory:

$$q = \sqrt{\frac{M}{8.54}} \quad \text{.....(Equation 1)}$$

$$A_s = \frac{M}{1020 \times q} \quad \text{.....(Equation 2)}$$

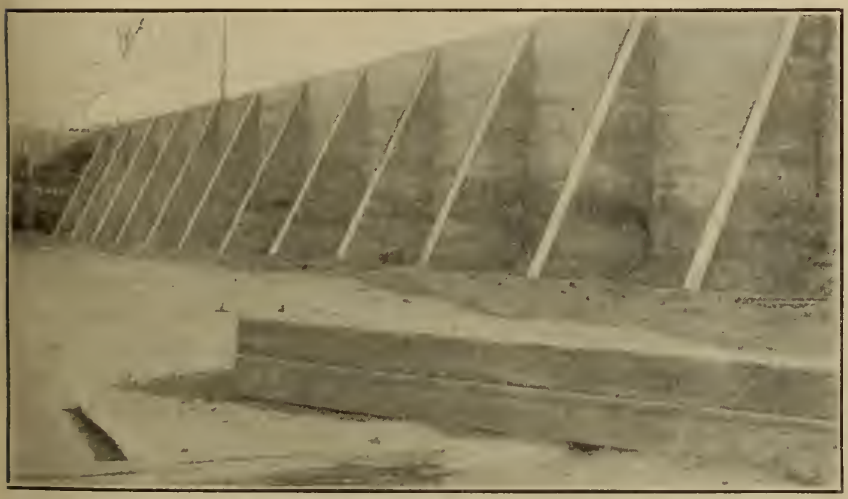
Where

q is the distance from the compression side of the beam to the steel, known commonly as the effective depth of the beam.

M is the bending moment in foot pounds per inch width of beam.

A_s is the area of the steel required per inch width.

View 1. South Wall Showing Steel Reinforcement and Outside Forms
Note Opening Left for Concreting



View 2. Finished South Wall

Equation 1 gives the effective depth of the beam when the bending moment is known and the reinforcement is fixed at 0.83 per cent of the area of the concrete above the steel. Equation 2 gives the amount of the steel reinforcement when the bending moment is known and the depth of the beam (q) is fixed. It can only be used when the percentage of steel reinforcement is 0.83 per cent or less.

DESIGN OF SIDE WALLS

The reinforcement in the side walls and their construction makes them partially continuous. The common theory of flexure as we know it is applicable to this case, but not with the numerical constants familiar to us. The allowance that is usually made in reinforced concrete construction for the increase in strength due to the partial continuity is a reduction of from 25 to 50 per cent in the bending moment computed on the basis of a simple beam. The exact amount of increase in strength due to partial continuity can be computed in any one case when all the factors are known. The process, however, is a very tedious one, and entirely unnecessary. A fair assumption as to the allowance can nearly always be made. In this case, on account of the small amount of reinforcement in tension over the counterforts, this reduction has been taken at 25 per cent.

For the design of a tank, equations 1 and 2 can be put in a more convenient form, as follows:

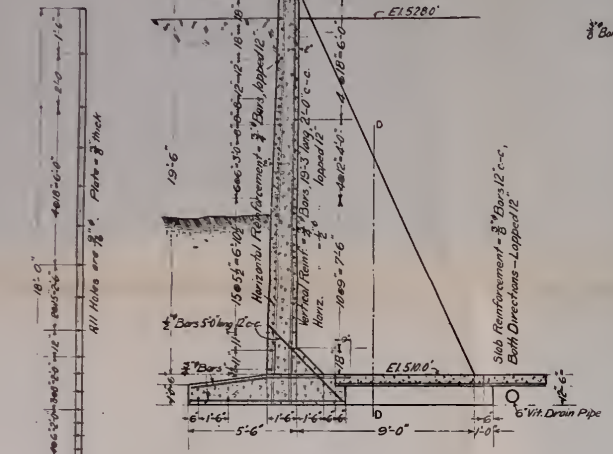
Replacing M by its value $\frac{(W \times X \times L^2)}{10 \times b}$, where W is the weight of the water, $62\frac{1}{2}$ pounds per cubic foot, X the depth of the water, L the clear span between counterforts, b the width considered, namely 12 inches, we get,

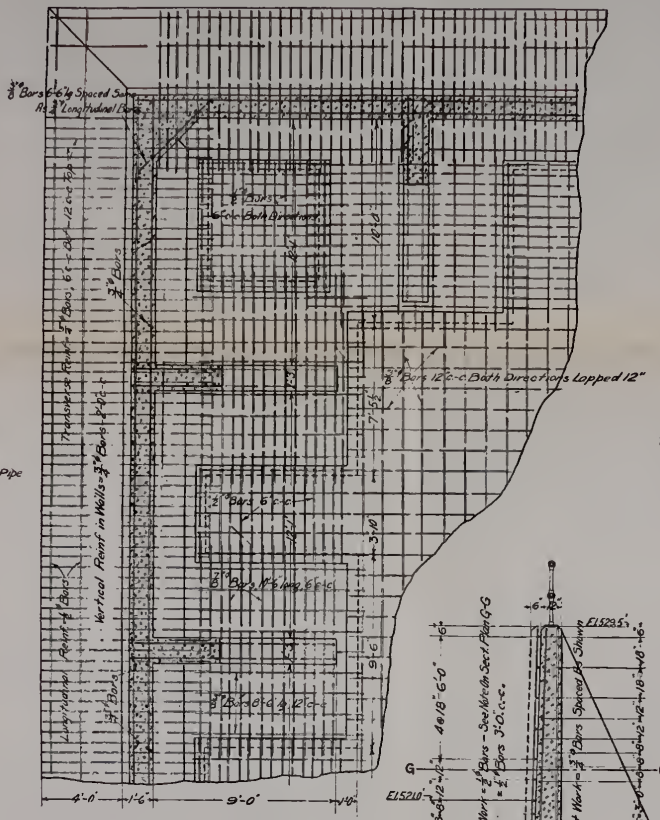
$$q = 0.247L \times \sqrt{X} \quad \text{.....(Equation 3)}$$

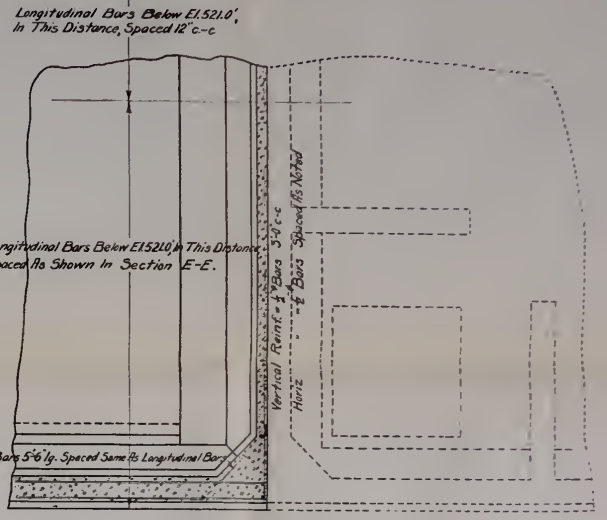
$$A_s = \frac{0.00051XL^2}{q} \quad \text{.....(Equation 4)}$$

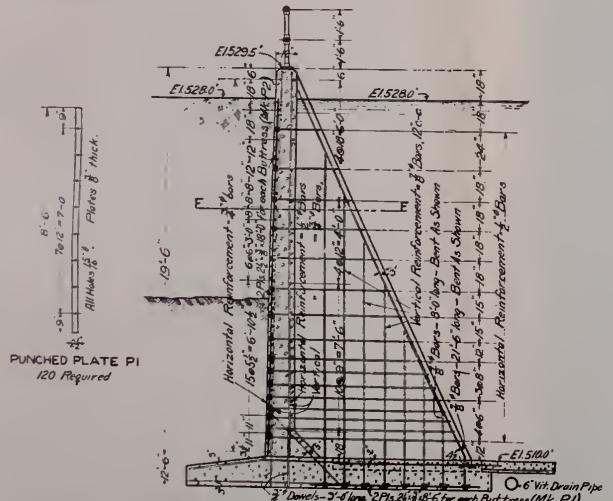
Equation 3 gives the minimum effective depth of the beam or slab at any depth (X feet) below the surface of the water. Equation 4 gives the amount of the steel reinforcement required per inch width of beam when the effective depth (q) is fixed. It cannot be used, however, when the percentage of steel reinforcement exceeds 0.83 per cent.

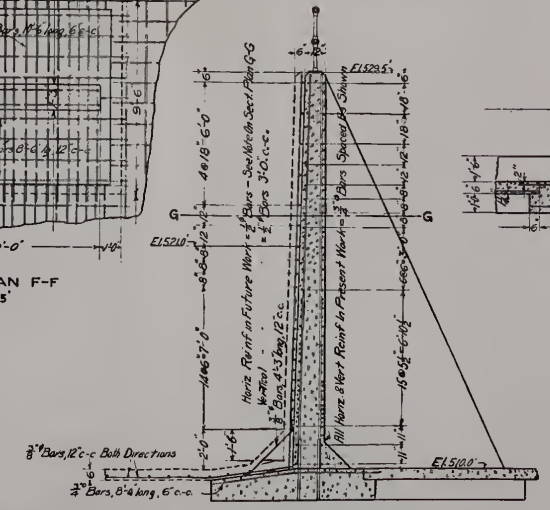
Figure A, shows the forces that are acting on the walls. The water pressure increased from zero at the water surface to a maximum of 1125 pounds per square foot at the bottom. Only a por-

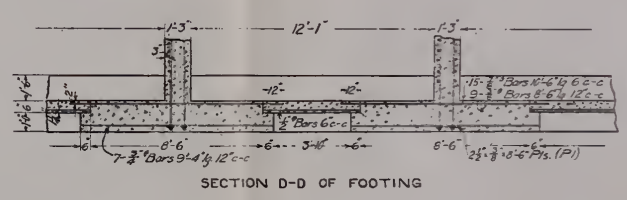

All Holes are ⅞", Plate = ⅜" thick.
PUNCHED PLATE P2
120 Required
E1.528.0'
E1.511.0'
6" Vit. Drain Pipe
Slab Reinforcement = ⅞" Bars 12" c-c, Both Directions - Lapped 12"
SECTION B-B SHOWING WALL REINFORCEMENT


⅞" Bars 6'-6" lg. Spaced Same As Longitudinal Bars
⅞" Bars 12" c-c Both Directions Lapped 12"
SECTIONAL PLAN F-F
AT ELEV. 522.5'


Longitudinal Bars Below El. 521.0', In This Distance, Spaced 12" c-c
Longitudinal Bars Below El. 521.0' In This Distance, Spaced As Shown In Section E-E.
⅞" Bars 5'-6" lg. Spaced Same As Longitudinal Bars
SECTIONAL PLAN G-G
AT ELEV. 522.5'
SHOWING FUTURE EXTENSION


All Holes ⅞". Plates ⅜" thick.
PUNCHED PLATE P1
120 Required
E1.529.5'
E1.528.0'
E1.510.0'
6" Vit. Drain Pipe
Transverse Footing Reinforcement - Top = ¾" Bars 8'-0" long 12" c-c Bent as shown
Bot. = ¾" " 7'-9" " 6" c-c.
Longitudinal " " - Top = 15 - ⅞" Bars 10'-6" long 6" c-c for ea Buttress Footing
Bot. = 2 - ½" " 18" c-c - Lapped 12" & 7-¾" Bars 9'-4" lg for ea Both. F'tg.
Transverse " " - Top = ⅞" Bars 8'-6" long 12" c-c for each Buttress Footing
SECTION C-C SHOWING BUTTRESS REINFORCEMENT


E1.529.5'
E1.521.0'
E1.510.0'
⅞" Bars, 12" c-c Both Directions
¾" Bars, 8'-6" long, 6" c-c.
Note: All Reinforcement Same As In Section B-B Except As Noted
SECTION E-E THROUGH CENTER WALL
SHOWING FUTURE EXTENSION IN DOTTED LINES


12'-1"
SECTION D-D OF FOOTING

tion of this pressure, namely, that portion marked "*a*" is carried by beam action to the counterforts. That portion marked "*b*" and shown by the dashed arrows, is carried by cantilever action directly to the footing. The diagram shows that the walls receive their maximum stress as a beam at a point approximately 15 feet below the water level. The minimum thickness of concrete wall that

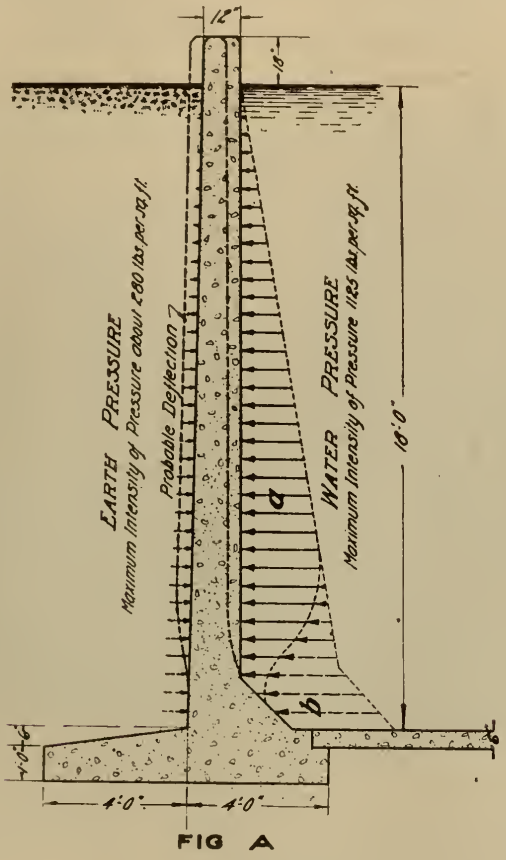


FIG A

it is possible to use under the conditions assumed is computed as follows from Equation 3; substituting in this equation, we have

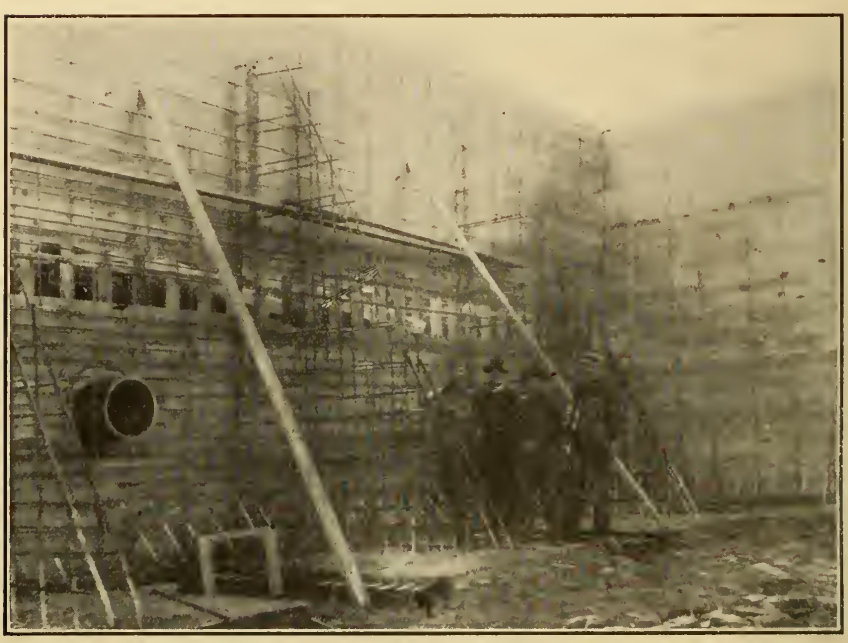
$$q = 0.247 \times 12.08 \times \sqrt{15} = 11.55 \text{ inches.}$$

Allowing $2\frac{1}{2}$ inches of concrete to cover the steel, we obtain a minimum thickness of 14 inches. Plate III shows the thickness of the wall at this depth to be 17 inches. On account of the low cost of the con-

crete materials and the comparatively high cost of the steel reinforcement, it was deemed more economical to use a heavier section than the minimum that could be used. In places where concrete materials are costly, it would be possible to construct the side walls 8 inches thick on the top and 15 inches thick at the bottom.

The amount of steel reinforcement, A_s, that would be required 15 feet below the water level, can be readily obtained by means of

$$\text{Equation 4; } A_s = \frac{0.00051\ XL^2}{q}.$$



View 3. Southwest Corner of Basin Showing Steel Reinforcement

Substituting for X, 15 feet; for L, 12.08 feet; and for q, 14.64 inches we obtain, $A_s = .0763$.

The spacing of $\frac{3}{4}$ inch round rods will be,

0.4418 (the area of a $\frac{3}{4}$-inch round rod) divided by 0.0763 (the amount of steel required per lineal inch), giving 5.79 inches as the spacing.

Plate III shows the spacing to be 5.5 inches at this point.

In Figure A is shown graphically by dotted arrows the earth pressure acting against the wall from the outside. It is proposed to back

up the walls of the basin on three sides as shown on the plan. As there is a possibility that this backing may be removed at any time, no allowance whatever has been made for the additional stability given to the tank by it.

Attention is called to the connection of the walls of the tank to the bottom. The pressure from within forces the side walls outward, the deflection reaching the maximum half way between the counterforts. The connection of the walls to the footing must be either a sliding joint to permit of this movement, which is impracticable, or sufficient reinforcement must be provided to prevent the possibility of rupture at this point. Figure A shows diagrammatically, but in a somewhat exaggerated form, the deflection of the side walls at the center of the span when the reservoir is full of water. The rigid connection spoken of is a concrete fillet 18 inches on the side reinforced with $\frac{1}{2}$-inch round bars spaced 12 inches on centers. This rigid connection transfers by cantilever action some of the hydrostatic pressure against the lower portion of the wall directly to the footing. The amount of this pressure transfer is shown diagrammatically by the dashed arrows in figure *A*, marked "*b*."

Figure B shows all of the forces except the earth pressure, acting on a section of the tank 13 feet 4 inches long, including one counterfort and half of the clear span of the walls on either side of it. The total weight of the concrete for this section is 106,150 pounds, with its center of gravity located 9 feet from the heel (*o*) of the footing. The total horizontal water pressure against this part of the tank is 135,000 pounds and the weight of the water resting on the footing is 150,000 pounds. Let us assume for the present that the sliding of the wall is prevented by the tension in the bottom. This tension amounts to 10,100 pounds per lineal foot of footing and is shown acting 1.25 feet above the bottom of the footing. All these forces are shown in their true position in the figure.

Since the forces shown acting on this portion of the structure are in equilibrium, we have

$$z = \frac{\Sigma M_o}{\Sigma V} \text{ or}$$

$$\begin{aligned}
106{,}150 \times 9 &= + \quad 955{,}350 \\
150{,}000 \times 5 &= + \quad 750{,}000 \\
135{,}000 \times 7.5 &= + 1{,}012{,}500 \\
135.000 \times 1.25 &= - \quad 168{,}750 \\
\Sigma M &= \quad 2{,}549{,}100 \\
\Sigma V &= \quad 256{,}150 \\
z &= \quad 9.95
\end{aligned}$$

This shows that the resultant pressure on the footing, namely 256,150 pounds pierces the base 9.95 feet from the heel, which is practically two-thirds of $15\frac{1}{2}$ feet, the width of the base. Consequently the distribution of the foundation pressure on the footing is in the form of a triangle, about as shown in the figure. It reaches a maxi-

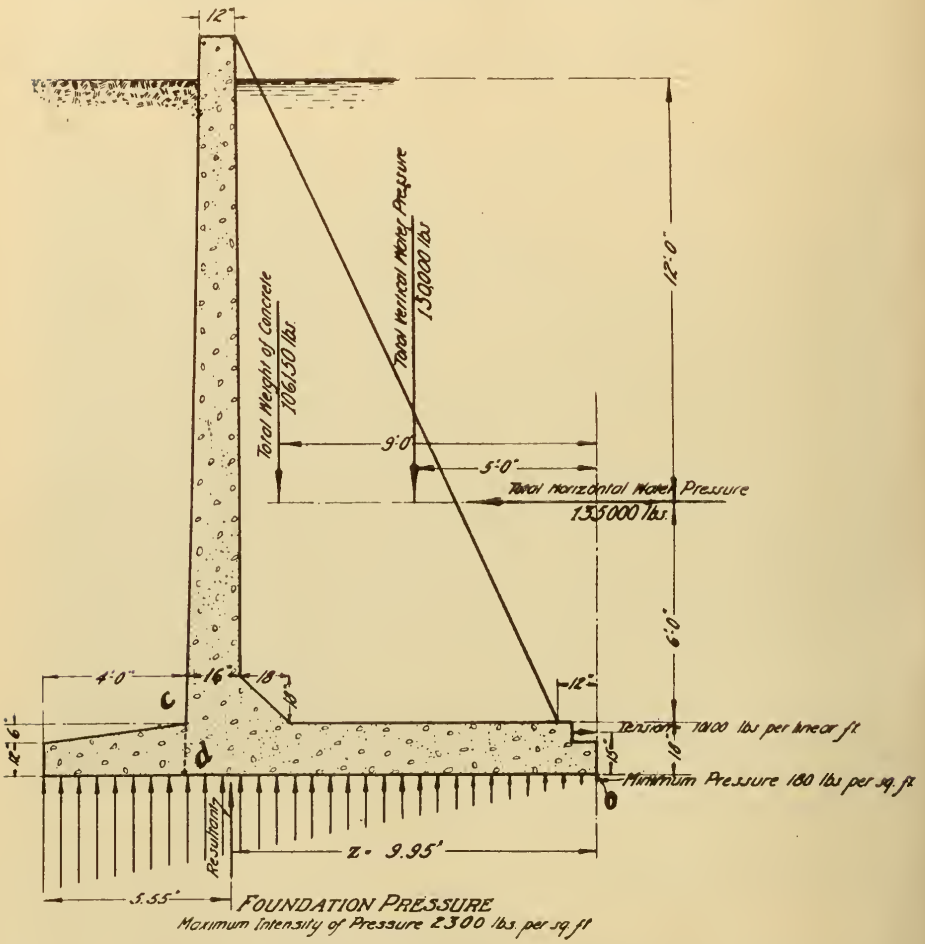
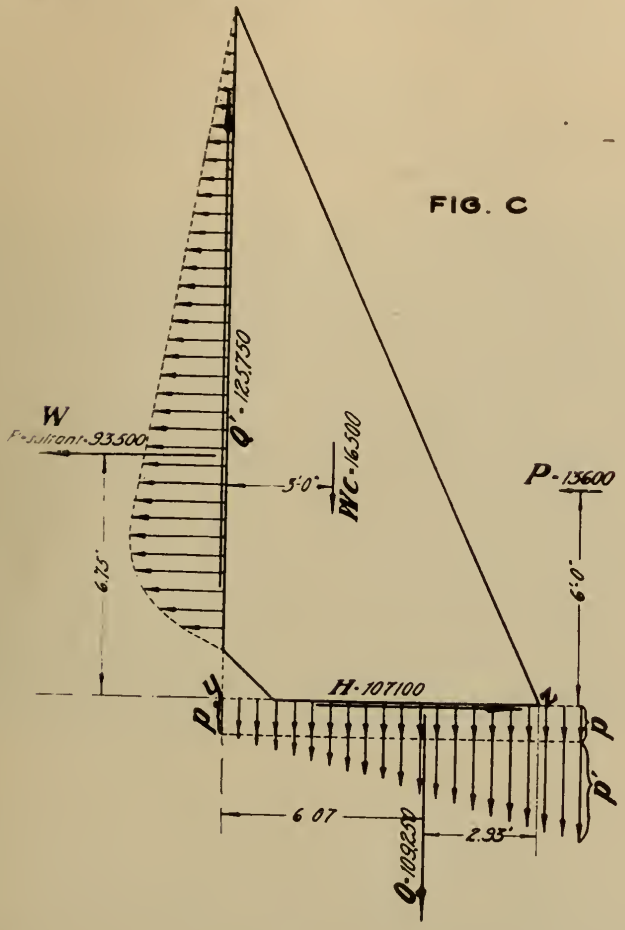


FIG B

mum pressure of 2,300 pounds at the toe and nearly zero at the heel. Sufficient steel is provided for in the bottom to take care of a tension of 10,100 pounds per lineal foot of footing where it joins the 6 inch concrete bottom. This reinforcement consists of $\frac{3}{8}$-inch round rods spaced 6 inches centers. The plan erroneously shows these bars to be

placed 12 inches centers. This amount of steel is sufficient to resist this tension at a unit stress well within the elastic limit of these steel bars. The author does not wish to convey the idea that this tension is developed to the extent shown in Figure B. A very large proportion of it will be developed by friction between the footing and the



supporting earth, and some by the earth backing, which, however, will not be always present.

DESIGN OF COUNTERFORTS

Figure C shows the forces acting on the counterfort proper. The reaction of the walls, tension in this case, amounts to 93,500 pounds,

and its distribution is about as shown in the figure. It reaches its maximum 15 feet below the water level. This tension is taken care of by thirty-two $\frac{1}{2}$ inch round bars at an average unit stress of 14,900 pounds. This is not a very high value. In the discussion we have ignored the additional stability received from the earth pressure, and also the tensile strength of the concrete in the counterforts, which may be considerable.

The greatest of care must be taken to anchor the walls to the counterforts. In this case, this has been done by threading the ends of the $\frac{1}{2}$-inch tension bars and fastening them with double nuts to two $2\frac{1}{2}$-inch $\times$ $\frac{3}{8}$-inch plates, 18 feet long, embedded in the walls, as shown in the reinforcing plan (Plate III). The object of the double nut is to prevent the possibility of play at the joint.

A study of this figure shows that the counterfort is not a cantilever at all. In a cantilever, the internal resisting forces acting on the plane yz, must balance algebraically, that is, the total tension must be equal to the total compression. This is not the case in the counterfort, as can be readily seen.

The forces that act on the counterfort are as follows:

W = the tension exerted by the walls on the counterfort, 93,500 pounds.

P = the horizontal pressure of the water acting against the counterfort proper, 13,600 pounds.

W_c = the weight of the counterfort proper, 16,500 pounds.

Q = the total tension between the footing and the counterfort along the plane yz, 109,250 pounds, shown acting 6.07 feet from the point Y.

Q' = the shear between the counterfort and the wall of the basin, 109,250 pounds plus 16,500 pounds.

H = the horizontal shear acting along the plane yz, 107,100 pounds.

The determination of the amount of the pressure Q and its distribution with reference to the plane yz, is a very interesting one, and is for this reason given in detail. Taking moments about a point, Y, we obtain the following equation:

$$93{,}500 \times 6.75 + 13{,}600 \times 6 - 16{,}500 \times 3 - p \times 10 \times 5 - \frac{p^1}{2} \times 10 \times \tfrac{2}{3} \text{ of } 10 = 0.$$

In this equation, there are two unknown quantities, p and p'. A safe assumption to make, since there is no tension at the heel (o) is that

$p + p'$ cannot exceed the sum of the weight of the water above the footing and the weight of the concrete itself. This amounts to 1,350 pounds per square foot of footing, thus giving the additional equation:

$$p + p' = 1350 \times 13.33$$

From these two equations we obtain

$$p = 3{,}850 \text{ pounds and}$$
$$p' = 14{,}150 \text{ pounds.}$$

The total resultant tension Q, and its location, can now be readily found, and is given in the figure as 109,250 acting 6.07 feet from y.

View 4. Southwest Corner of Basin Finished; South Wall Stripped

This tension of 109,250 pounds is taken care of by sixteen $\frac{7}{8}$-inch round bars at an average unit stress of 11,350 pounds. The maximum stress in these bars probably reaches 14,000 pounds per square inch. The bars are anchored in the concrete footing by two $2\frac{1}{2}$-inch $\times \frac{3}{8}$-inch plates 8 feet 6 inches long, to which they are fastened by double nuts.

The distribution of the pressure along the plane yz is a more or less indeterminate one. It depends principally upon the shape and the reinforcement of the footing course. Only in a very special case will its distribution be such as to make the counterfort a cantilever. The method so often followed of designing a counterfort as a cantilever

and placing all the steel reinforcement in the back of the counterfort, is an erroneous one. It places in the footing course a concentrated and rather high tension, and at a point where it cannot properly be taken care of, thus producing enormous secondary stresses in the footing, which would be a serious defect in the structure.

CORNER DESIGN

The reinforcement of the corners of the settling basin is of some interest. This reinforcement consists of a triangular concrete fillet

VIEW 5. INTERIOR VIEW LOOKING WEST; SHOWING CONSTRUCTION OF THE BOTTOM AND WEST WALL, INCLUDING COLLECTING TROUGH

24 inches on each side, reinforced with $\frac{3}{8}$-inch round bars, each 6 feet 3 inches long, and spaced the same as the $\frac{3}{4}$-inch horizontal reinforcement in the walls of the basin. The adhesion between the steel and the concrete is counted upon to securely tie in the corner. No rigid connection whatever is used for the reinforcement.

FOOTING DESIGN

The footing overhangs the wall for a distance of 4 feet. It is 18 inches thick at the point where it joins the wall and narrows down to

12 inches at the outer end. The following computations give some idea as to the methods used in designing this footing.

The upward pressure on the overhanging portion ranges from 2300 pounds per square foot to 1750 pounds per square foot. The thickness of the footing at *c-d*, figure B, should be sufficient to keep the shearing stress down to a safe working value. The total upward pressure per lineal foot of footing course, amounts to 8100 pounds. This gives an average value for the shear of 37.5 pounds per square

View 6. Interior View During Construction Looking East

inch, a very safe value. Equation 2 can be used to compute the amount of steel required, as follows:

$$A_s = \frac{M}{1020 \times q}$$

where M represents the bending moment in foot-pounds per lineal inch of footing at the plane *c-d*, which amounts to 1410 foot-pounds.

q is 18 inches minus 3 inches.

Substituting in this equation, we obtain for A_s .0922 square inches. This amount of steel requires a spacing of 4.80 inches for $\frac{3}{4}$-inch round bars. A spacing of 6 inches is shown on the plan. The spacing used is considered ample, as the computations just outlined do not take

into consideration the weight of the overhanging footing nor the weight of the earth backing.

The above general outline of the methods used in designing the settling basin conveys some idea of the thoroughness and carefulness with which a structure of this type must be designed.

JOINTS

Horizontal construction joints are used freely. The unfinished surface is always left in as rough a condition as possible, but never roughened up after the concrete has partially set. The author has found that this roughening often loosens the stone in the concrete, but not sufficiently so that they can be removed, a condition which is apt to impair the watertightness of the structure. To start a day's work, the surface is thoroughly cleaned with wire brushes and water, and a cement liquid mortar mixed in the same proportions as the mortar in the concrete, is poured over the old work to a depth of $\frac{1}{2}$ inch. This method always gives a good watertight horizontal construction joint.

Vertical joints are permitted only in certain places, as these joints are very difficult to make watertight. All vertical joints in the walls are made directly over the counterforts.

CEMENT WASH

The specifications call for two coats of neat cement wash to be applied with a whitewash brush on the inside of the basin. Both of these coats are to be applied to the concrete when damp, but not wet, and the second coat must be applied before the first one has had time to get very hard. Any leakage that may develop in the basin previous to its final acceptance, must be repaired by the contractor, at his own expense, no additional compensation whatever being permitted for this work under the specifications. The contractor, realizing the importance of doing conscientious work all the time to prevent subsequent trouble from leakage, is producing a first class structure. The work is being done so thoroughly that very little leakage, if any, is expected when the basin is filled for the first time this summer.

The following is an approximate estimate of the quantities of material required, together with the contract unit prices:

18,000	cubic yards of earth excavation	@ $0.40	$7,200.00
1,930	Cubic yards 1:2:4 concrete	@ 6.25	12,062.50
820	Cubic yards 1:3:6 concrete	@ 5.40	4,428.00
4,000	barrels of cement	@ 1.40	5,600.00
220,000	pounds of steel	@ 0.035	7,700.00
3,520	feet 3 inch vitrified sewer pipe	@ 0.20	704.00
800	feet 6 inch vitrified sewer pipe	@ 0.20	160.00
220	feet 24 inch vitrified sewer pipe	@ 3.50	770.00
1	manhole complete		50.00
160	feet 12 inch cast iron pipe	@ 2.25	360.00
40	feet 18 inch cast iron pipe	@ 4.00	160.00
380	feet 36 inch cast iron pipe	@ 8.00	3,040.00
28,000	pounds cast iron specials	@ 0.05	1,400.00
5	12 inch valves (gate valves)	@ 30.00	150.00
6	18 inch press. equalizing valves	@ 12.00	72.00
1	24 inch tidal valve	@ 18.00	18.00
485	feet 1½ inch pipe railing	@ 0.60	291.00
	Superstructure for valve chamber	@	500.00
1,000	pounds wrought iron and steel	@ 0.05	50.00
300	feet ¾ inch galvanized wrought iron pipe	@ 0.30	90.00
		Total,	$44,805.50

The author acknowledges the assistance of his principal assistant engineer, Mr. A. H. Beyer, in connection with the development of the details of this construction. Mr. E. S. Whitney has acted to date as resident engineer on the construction of this work.

DISCUSSION

Mr. Edward Wegmann: The speaker might say a word or two about the use of reinforced concrete in hydraulic structures. Quite recently he was called upon to prepare plans for a dam in the mountains of West Virginia, at the end of a log railroad. A comparative estimate showed that a reinforced concrete structure would be decidedly the cheapest kind of a dam. One point that arose was, what is the life of such a structure? Some engineers believe that, in the course of time, the steel in reinforced concrete will corrode; others are of the opposite opinion. The oldest reinforced concrete dam is not much over eight years old, and the question was whether the speaker should recommend a construction that possibly in ten or twenty years might prove to be a failure. He employed a prominent engineer who was decidedly opposed to that kind of construction, and asked him to advance every argument that he could against the use of reinforced concrete for such a purpose. Then the speaker got an enthusiastic advocate on the other side to also brief his arguments. After

careful consideration the speaker decided to build a reinforced concrete dam of the Ambursen type, and the question was discussed whether he could not make assurance doubly sure as regards watertightness by using some waterproofing compound. He examined about six different compounds. It may interest you to know that the prominent companies who make these compounds were so confident that they could make the dam absolutely waterproof, that they were willing to put up a guarantee for five years that the concrete would be absolutely waterproof, the penalty in case of failure being that they would return the money with 4 per cent interest. Samples of different waterproofing compounds were obtained and tested at the Rensselaer Polytechnic Institute, at Troy, New York. At the same time, Mr. Jackson, of the department of water, gas and electricity of New York City, was making similar tests. The tests made for the speaker did not cover a sufficiently long period of time to make them absolutely conclusive, but they showed that after a period of thirty-eight days, the compounds reduced in every case the tensile strength of the cement; in some cases as much as 10 per cent. Mr. Artingstall, in a paper read before the Western Society of Engineers, stated that some of the compounds tested by him had deteriorated the cement, but that the one finally selected, increased the strength of the cement 50 per cent. It was not mentioned whether that was the strength under compression or tensile strength. The 2 x 2 x 2-inch cubes used by the speaker for compressive tests were really too small to give reliable results. As the tests for tensile strength showed always a diminution of tensile strength, it was decided to give up the idea of using an integral compound in the dam in West Virginia. However, if necessary, the structure can be easily coated on the water side with certain waterproofing compounds at about one-third or one-quarter the expense of using integral waterproofing. Three prominent companies varied only 1 cent per barrel from each other in bidding for the integral waterproofing; one bidding 56, the other 55 and the third 56 cents per barrel; for which price they agreed to regrind the cement at the dam, with an integral compound, or to arrange with the mill to have it ground. It shows there was pretty close competition.

There is a certain sweating that we find in the Ambursen dams, or moisture, which may be due to condensation. The speaker's opinion is that with the tight concrete that is obtained by using wet mixtures, with the few hair cracks that may occur, if corrosion does exist it will form a coating that will stop all further rusting.

Mr. W. F. Wilcox: We have just finished a dam that has been under pressure about a year. This dam is 104 feet high and 500 feet long and the water stands against it 87 feet above the bottom of the creek. Every 80 feet longitudinally this dam is cut entirely in two and the sections are joined by a male and female joint.

The question was to get some substance that would be watertight and at the same time be elastic in making those joints. We tried several preparations. The speaker does not care to name them because they all failed. We made a box 2 x 2 x 4 feet, to hold two 2-foot concrete cubes, painted the end of the first cube with a mixture that was furnished and then built the second cube and let both dry then dropped the 2 x 2 x 4-foot concrete block from a height on to a smooth surface. We found that in some of these tests the crack was generally on the line of the juncture, but in some samples the concrete broke rather than the mixture. As another effort towards getting a water-tight joint we took ordinary number 6 paving pitch such as you see used every day in filling the joints in brick pavement, and applied it hot between the 2-foot cubes, dropped the cubes from the same height as before, and could see the joint fall apart just like molasses candy pulls.

This dam has been under water pressure about a year with 81 feet of water against it. We have observation holes 3 feet in diameter, and we have sent men down in these holes and have found that there is no leakage at all. Our dam is remarkable in the fact that there are no cracks in it, the only leakage that we have found in there is capillary, supposedly through the slag which we used in the concrete. The water that comes through the dam comes in the form of a sweat, it does not run in streams, but is just like the moisture on the window panes, you can take your handkerchief and wipe it off. Where this water comes through carbonate of lime forms on the outside face of the dam, which to the speaker's mind is an indication that the water has soaked through, but not that there is a fissure, because if there were any fissures inside, the carbonate of lime would be deposited inside instead of on the face of the dam.

At the point where the dam is joined together, where we used this number 6 paving pitch, we found absolutely no leakage. In our high level reservoir, 22 feet deep, in putting in the bottom and sides we put in blocks 6 inches thick by 10 feet square, in checker board fashion, and after the first sections were down we painted their edges with hot number 6 paving pitch, and then put in the other sections. There was a fillet space left in the top of these joints, about 6 inches wide and

3 inches deep. After the last section of blocks was put down we painted this open section with number 6 paving pitch, and filled it up with concrete. From the observations we have been able to make all around the walls we cannot find any leakage. By testing the depletion of the water in the reservoir we found it to practically correspond with our evaporation test. This is favorable to the use of number 6 paving pitch, which is easily applied and costs very little. The speaker's recollection is that we paid about $14 a ton for it delivered at the work.

President Gwinn: Another feature of Mr. Potter's paper which is especially interesting and upon which we would like to have some discussion is the method of settling the water, not from a construction standpoint but the method of operation. Mr. Potter probably has some rather original ideas in that regard, and as it is a very important feature we would like to hear some discussion on it. Mr. Potter, have you tried this reservoir? Is it completed?

Mr. Alexander Potter: It is not completed as yet. It is on the same lines as those adopted at McKeesport and Georgetown, which are working very satisfactorily.

Mr. C. B. Salmon: Have you any drain under the collecting chamber outside?

Mr. Alexander Potter: No, sir.

Mr. C. B. Salmon: Don't you find there is a considerable collection of filth and dirt in the collecting chamber?

Mr. Alexander Potter: A deposit is found in the distributing chamber, but the collecting chamber is practically free from deposit. The sludge accumulating in the collecting chamber is stirred up from time to time with wire brushes, and is carried forward into the settling basin with the raw water. The sludge is precipitated in the first compartment of the settling basin, and is drawn off through the underdrain system with the rest of the precipitated sludge.

Prof. Edgar B. Kay: The speaker would like to ask Mr. Potter to give the convention the specification which he uses for the steel in this reinforced concrete work. It is very important from an engi-

neering standpoint to know the physical characteristics of the steel that is used in any reinforced work, and therefore the speaker would ask what Mr. Potter's specifications are?

Another question the speaker would like Mr. Potter to answer is, the method which he employs in making this long monolithic construction in the bottom of the reservoir, and the manner in which his reinforcement is connected together, whether it is overlapping, or whether there is merely a mechanical bond between the steel, in making these long lines which are shown in the design?

MR. ALEXANDER POTTER: In constructing the bottom of the reservoir no mechanical bond was employed. The ends were overlapped thirty diameters. Round deformed bars were used throughout the work.

Did not incorporate the specifications in my paper; assumed that they would make the paper unnecessarily long. As Professor Kay asks for them, will submit them for incorporation in the discussion.

SPECIFICATIONS

Where used. Under Item 6 the contractor shall furnish in place all the steel reinforcements, punched plates, and rods with threaded ends and double nuts, shown on the plans, including the wires necessary to hold the steel reinforcement in place.

Description. All steel used for this purpose shall be of the shapes, weights and sizes shown on the drawings or ordered. Only bars possessing mechanical bond of types which have been in successful use a large number of years in large engineering works in America shall be used.

Mechanical and physical properties. The bars shall be made of high carbon steel, by the Bessemer process, and shall be rolled from billets, and shall conform to the following chemical and physical properties. The maximum allowable phosphorus shall not exceed C.10 per cent; the minimum ultimate tensile strength shall be at least 50,000 pounds per square inch; and the minimum percentage of elongation in 8 inches shall be $\frac{1{,}000{,}000}{\text{Ult. Strength}}$. Bars $\frac{3}{4}$ inch in size or under shall bend cold without cracking 180 degrees to a diameter equal to four times the nominal size of the reinforcing rod. Sizes $\frac{3}{4}$ inch and larger shall bend cold 90 degrees to a diameter equal to four times the nominal size of the rod. For the purpose of these specifications, the yield point shall be determined by the careful observation of the drop of the beam of the testing machine.

Chemical determination. In order to determine if the material conforms to the chemical limitations described in the foregoing paragraph, analysis shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt or blow of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector.

Type of deformed bar acceptable. At no point must the area of cross section of a bar be less than the area of a circle of the diameter specified. Tensile and bending tests shall be made on both planed and unplaned specimens to determine the reduction in strength of the deformed bar over the plain bar. Any type of deformed bar which shows a considerable reduction in strength over the plain bar possessing the same area of cross section and made of the same material, will not be accepted.

Tests. Planed specimens shall be turned for a length of at least 9 inches in order to secure a uniform cross section. At least one tensile and one bending test shall be made from each melt or blow of steel rolled. In case bars differing $\frac{3}{8}$ inch and more in diameter or thickness are rolled from one melt or blow, a test shall be made from the thickest and thinnest material rolled. Should either of these test specimens develop flaws, or should the tensile test specimen break outside of the middle third of its gauged length, it may be discarded and another test specimen substituted therefor. In case test specimens do not meet the specifications, additional tests may be made and if satisfactory, material shall be accepted.

Modifications in elongation for thick material. For each increase in diameter of $\frac{1}{8}$ inch or in thickness above $\frac{3}{4}$ inch, a deduction of one shall be made from the specified percentage of elongation.

Finish. Finished material must be free from injurious seams, flaws or cracks, and have a workmanlike finish.

Bending. All bars shall be bent and cut to the exact shape and size shown on the plans. Every precaution, including the use of modern appliances, shall be taken in bending the steel reinforcement to the required shape. Sharp bends are prohibited. All bends must be made with smooth curves to a radius of not less than ten times the thickness of the reinforcing bar.

Lapping of reinforcements. All bars shall be lapped thirty diameters. Only in special cases shall this distance be increased or decreased, and then only in accordance with the direction of the engineer. The bars shall be lapped only in those places shown on the drawings, and where permitted by the engineer. It will not be permitted to splice bars of lengths less than 30 feet except with the permission of the engineer.

Placing steel in concrete. Before beginning concreting all steel reinforcements shall be placed in the exact position and with the spacing shown on the drawings, or ordered, and it shall be so fastened in position by wiring the bars where they cross, as to prevent their becoming displaced during the placing of the concrete.

Protection of steel. Steel for reinforcement shall be new unrusted stock, free from mill scale, delivered without rust, other than may have accumulated in transportation to the work. It shall at all times be thoroughly protected from moisture until placed in final position. Furthermore, after placing in position, if concreting be interrupted for any considerable number of days, the steel shall be protected with canvas or tarred paper, or other satisfactory covering. Ends of rods that are to be left projecting for a considerable time shall be painted with a heavy coat of neat cement grout.

Compensation for reinforcing concrete. The quantity of metal to be paid for under Item 6 shall be the number of pounds of reinforcing metal actually placed in accordance with the drawings, or ordered. It shall not include any

waste metal due to the fact that the lengths supplied are too long for their purpose. The quantity paid for shall, however, include extra metal inlaps, where authorized by the engineer, due to the fact that a single bar would be unreasonably long. In computing the weights, the area of the bar shall be taken as the area of a circular section of the same diameter; 1 cubic inch of steel shall be reckoned 0.283 pound. The compensation shall include the cost of metal, including any royalty, the cutting, placing, furnishing wire, fastening in position, coating with cement, and all other work and materials connected therewith.

Prof. Edgar B. Kay: Isn't it a fact, Mr. Potter, that in all reservoir work you have found the plain (round) rods more satisfactory than patented rods rolled or twisted in various forms?

Mr. Alexander Potter: The speaker does not think Professor Kay's expression in styling all rods which are not plain rods, "patented bars," the best one that could be used. We are often obliged to use patented articles in connection with municipal work, and when this is necessary, an engineer should have no hesitancy in doing so. However, there is so strong a prejudice against the use of patented material in municipal work that we should avoid any unnecessary use of the expression.

There are a great many deformed bars upon the market which are not patented. The original patent on the twisted bar has long since expired. A twisted or deformed bar costs no more than a plain bar. How much greater value the deformed bar has over the plain round bar in actual construction, it is difficult to determine. That it has theoretic advantages is unquestionably true. When, therefore, these bars can be procured at the same price as plain bars, the speaker believes it is good judgment to use them in preference to plain rods. The advantage that the deformed bar has over the straight bar is that there is a more uniform distribution of the stresses throughout the entire mass.

Mr. F. H. Shaw: The speaker would like to ask if you carried on the work on your walls continuously until they were completed; that is, if your men worked night and day shifts?

Mr. Alexander Potter: The work was not carried on continuously until it was completed. Whenever it was necessary to stop off for the night, before beginning work on the following day the surface of the concrete was brushed off and a cement grout poured over the surface. As stated in the paper, this was considered preferable to roughening the surface with a pick.

TURBINE DRIVEN CENTRIFUGAL PUMPS FOR WATER WORKS SERVICE

By W. O. Beyer

It is only recently that centrifugal pumps have received the serious consideration of water works engineers, although their economy and efficiency have long since been demonstrated for supplying water in large quantities to industrial plants. It is our purpose here to show that the combined fixed charges and operating costs of the rotatory unit compare favorably with those of the high duty vertical triple-expansion unit or other type, where the price of coal is not excessive.

The high duty shown by reciprocating engines in water works service, involving the pumping of large quantities of water against a constant head, without any great variation in rate, has long and justly been regarded as a supreme achievement. Due to the direct connection of the pump and engine cylinders and to the high efficiency realized in the unit when the proper attention is paid to its valves and packings, the triple-expansion reciprocating pumping engine has been able to develop duties that are unapproachable by rotatory units consisting of turbines and centrifugal pumps. However, a careful comparison of the total costs of pumping will show that the balance may be entirely reversed when fuel costs do not exceed a certain price per ton. That is, the high first cost of the reciprocating unit, together with the cost of the foundation required, introduce annual charges for interest, upkeep and depreciation which more than offset the lower duty of the turbine unit.

Of the several types of pumping engines the following are chiefly used for water works service; low duty compound condensing engines, costing with foundations, piping and appurtenances about $2300 per 1,000,000 gallons capacity per twenty-four hours; low duty triple expansion condensing horizontal engines, costing about $2800 per 1,000,000 gallons capacity; cross-compound condensing horizontal flywheel engines, costing about $3300 per 1,000,000 gallons capacity; and high duty triple expansion vertical condensing engines, costing about $4800 per 1,000,000 gallons capacity. The figures given are from a paper presented before the American Society of Civil Engineers, May 17, 1911, by the late Charles A. Hague. Since this paper

selected the high-duty triple-expansion vertical engine as the only one to be considered in most cases, it is with this type of engine that we shall make our comparison.

The prices for pumping units given below are to the best of our knowledge accurate and include condensers, piping and foundations complete.

No account has been taken of the greater volume required in the buildings for reciprocating units—as a unit volume cost must be assumed which would agree with only one architectural design; similarly no account has been taken of the greater volume required for the larger boiler installation of the turbine units, for the majority of existing plants usually have their building proportions determined and a saving could not be made in either room without special complications of no account in this discussion. However, the difference in cost of foundations has been taken into account, because this is an addition in existing buildings and can be computed easily.

In a new station the turbine should be credited with any saving in floor space, buildings, etc., which it may effect as compared with the reciprocating engine, and the reciprocating engine credited with the saving effected in the boiler rooms.

In a comparison of this kind certain assumptions must necessarily be made. We have tried to eliminate as far as possible arbitrary assumptions, and all figures of first cost of apparatus have been taken from, or estimated from recent bids on the two types of machinery under consideration. The first cost per boiler horse power we have taken to be $30, complete with piping, chimney, stokers, etc. The use of a lower figure would favor the turbine driven pump as compared with the high duty engine, but we believe with everything taken into consideration, this will prove to be an average figure. We have assumed the following annual charges against pumping machinery:

	Per cent
Interest	5
Depreciation	3
Repairs and supplies	2
Total	10

We have also assumed the following annual charges against the boiler equipment:

	Per cent
Interest	5
Depreciation	5
Repairs and supplies	5
Labor on maintenance	2
Total	17

It will be noted in the above that an annual depreciation of 3 per cent has been taken on the first cost of both the crank and fly-wheel and turbine driven unit, equivalent to a life of $33\frac{1}{3}$ years. We have chosen this method rather than one in which the capital charges are figured on a constantly decreasing book value for the pumping machinery and boilers, in order to avoid a complicated method of accounting.

For the reason that less data are available on the life of turbine driven units, than on crank and flywheel units, it is possible some objection may be made to this assumption of a life of $33\frac{1}{3}$ years for each machine. However, as in neither case the question of obsolescence has been taken into account, we believe the assumption a fair one. Viewed in the light of possible future development, it would seem that a longer life should be accorded to the turbine driven unit than to the crank and flywheel unit, as a very thorough canvass of the whole field of pumping equipment does not bring to light any mechanical apparatus which is being developed to compete with the turbine driven machinery to the same extent as the turbine driven machinery is being developed to compete with the crank and flywheel machinery.

It further appears that the steam turbine has reached a stage of development such that improvements will appear only as refinements of type, and steam economies can only possibly be reduced sufficiently to render obsolete the present good designs, by better theoretical design and by better steam conditions. The use of high steam pressures and superheat may be expected to gradually obtain further favor in this country as in European practice, where 250° F. superheat and 200 pounds steam pressure are not unusual. This however, entails practically no change in turbines as constructed for present steam conditions.

Fuel costs are based on a boiler efficiency of 65 per cent, heat content of 13,000 B.t.u. per pound of coal and twenty-four hours per day operation.

The duties given are on a basis of 150 pounds steam pressure with no superheat.

Three examples are taken based on coal at $2, $3 and $4 per ton. Where coal can be obtained cheaper than $2 per ton the advantages of the turbine driven pump are more clearly marked.

TABULATION "A"

8,000,000 G.P.D.—350 feet head—491 W.H.P.

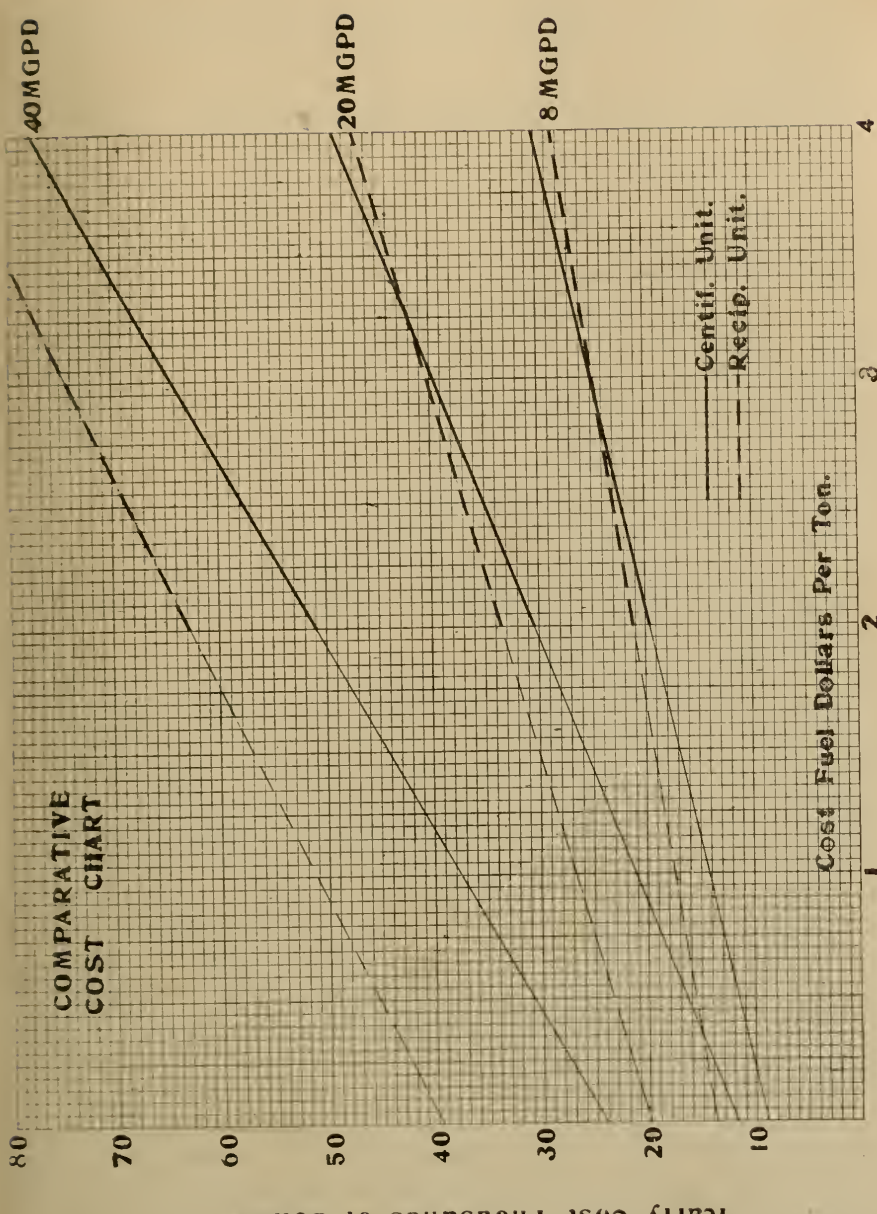
ITEM	VERTICAL C. & F. W. TRIPLE EXPANSION, 150,000,000 DUTY, 3–125 HP. BOILERS	STEAM TURBINE CENTRIFUGAL, 105,000,000 DUTY 3–175 HP. BOILERS
Cost pumping unit	$72,000	$16,000
Interest, depreciation, etc., 10 per cent	7,200	1,600
Cost boilers	11,250	15,750
Interest, depreciation, etc., 17 per cent	1,915	2,680
Labor, 3 shifts Engines	2,700	2,700
Labor, 3 shifts Boilers	1,800	1,800
Total interest, depreciation, etc., and labor	13,615	8,780
Fuel cost, $2 per ton	7,467	10,700
Fuel cost, $3 per ton	11,129	16,100
Fuel cost, $4 per ton	14,934	21,400
Total annual cost, $2 coal	21,082	19,480
Total annual cost, $3 coal	24,744	24,880
Total annual cost $4 coal	28,549	30,180

TABULATION "B"

20,000,000 G.P.D.—280 feet head—981 W.H.P.

ITEM	VERTICAL C. & F. W. TRIPLE EXPANSION, 165,000,000 DUTY, 3–225 HP. BOILERS	STEAM TURBINE CENTRIFUGAL, 120,000,000 DUTY, 3–300 HP. BOILERS
Cost pumping unit	$120,000	$26,000
Interest, depreciation, etc., 10 per cent	12,000	2,600
Cost boilers	20,250	27,000
Interest, depreciation, etc., 17 per cent	3,440	4,590
Labor, 3 shifts Engines	2,700	2,700
Labor, 3 shifts Boilers	1,800	1,800
Total interest, depreciation, etc., and labor	19,940	11,690
Fuel cost, $2 coal	13,570	18,630
Fuel cost, $3 coal	20,335	27,945
Fuel cost, $4 coal	27,140	37,260
Total annual cost, $2 coal	33,510	30,320
Total annual cost, $3 coal	40,275	39,635
Total annual cost, $4 coal	47,080	48,950

It will be noted that the point at which the total annual costs are equal for the 8,000,000-gallon crank and flywheel vertical unit, and the 8,000,000-gallon turbine centrifugal unit is when coal costs $2.91 per ton. Also for the 20,000,000-gallon vertical crank and flywheel unit, and the 20,000,000-gallon turbine centrifugal unit, the


COMPARATIVE COST CHART
40MGPD
20MGPD
8 MGPD
Centif. Unit.
Recip. Unit.
Cost Fuel Dollars Per Ton.
Yearly Cost Thousands of Dollars.
80
70
60
50
40
30
20
10
1
2
3
4

total annual costs will be equal when coal costs $3.25 per ton. Above these points the reciprocating unit has the advantage and below these points the rotatory unit has the advantage on the basis of these calculations.

We believe it can be assumed safely that the development of pumping machinery in the future will be along somewhat the same lines as the development of power producing machinery. At the present time one of the most noticeable features in the development of power machinery is the increasing favor with which larger units are being adopted. In large central station work five years ago, the ordinary size of unit was from 10,000 to 15,000 kw. Now, not only in European practice, but also in American practice, 25,000-kw. units are being installed in the large stations. There are two reasons for this development, the first being the continual endeavor to obtain better economy, not only in actual steam consumption, but in capital charges, including first cost, buildings, real estate, etc. The second reason for the development along this line comes from the fact that engineers of today seem to have more initiative than formerly and where before the development of a 15,000-kw. turbine would have seemed an impossible task, now the installation of 25,000-kw. turbines is becoming a matter of course.

We have assumed that there will be progress along this line in water works pumping machinery and that installations of very large units will be made in the future. We have evolved a comparison between two units of the types under consideration, each having a capacity of 40,000,000 gallons per twenty-four hours, against a total head of 300 feet. This comparison is based on utilizing the greatest range of steam temperature which the best modern practice has established as commercially practicable, and which at the same time is not too intensely theoretical. We refer here to European practice in which steam pressures of 200 pounds 275° superheat, and 28.5 inch vacuum are successfully and commercially utilized. Especially important in this connection is the item of high vacuum since in the case of water works large quantities of water are always available for condensing purposes.

Extremely large capacities and high heads present no difficulties, nor disproportionate costs in the construction of steam turbine driven centrifugal pumping units, since it is an inherent characteristic of the centrifugal pump that the larger the capacity the greater the efficiency for a given head.

There is practically no development necessary on the turbine to

take advantage of these conditions, as the turbine of almost exactly the same characteristics that would be necessary for this installation is now in successful operation in hundreds of power producing plants today. We have had to assume no steam consumption, as this is a matter of test, and practically have had to assume no pump efficiencies, as we have taken the minimum, which we know can be obtained on this size pump.

Further the turbine is well adapted to take advantage of the improvement in steam conditions as mentioned above, and reciprocating engines can also be designed to take advantage of the initial and terminal conditions favoring high economy.

The results of this comparison are shown in table "C." It is apparent from these tables that the point at which the two curves of overall economy of the two units cross, is at a cost of approximately $8.80 per ton for coal.

TABULATION "C"

40,000,000 G.P.D., 200 pounds steam pressure—300 feet head, 275° F. superheat—2120 W.H.P., 28.5 inch vacuum

ITEM	VERTICAL C. & F. W. TRIPLE EXPANSION, 223,000,000 DUTY, 3-350 HP. BOILERS	STEAM TURBINE CENTRIFUGAL, 193,000,000 DUTY, 3-400 HP. BOILERS
Cost pumping unit	$210,000	$55,000
Interest, depreciation, etc., 10 per cent	21,000	5,500
Cost boilers	31,500	36,000
Interest, depreciation, etc., 17 per cent	5,360	6,100
Labor 3 shifts Engines	7,200	7,200
Labor 3 shifts Boilers	5,320	5,320
Total interest, depreciation, etc., and labor	39,480	24,120
Fuel cost, $2 coal	23,265	26,800
Fuel cost, $3 coal	34,897	40,200
Fuel cost, $4 coal	46,330	53,600
Total annual costs, $2 coal	62,475	50,920
Total annual costs, $3 coal	74,377	64,320
Total annual costs, $4 coal	85,810	77,720

It would therefore appear that the field of these large capacities at high heads for ordinary coal costs, belongs to the turbine driven centrifugal pump exclusively.

In conclusion, if the above data are correct—and it has been our sincere endeavor to present only such figures as are fair for both types of machines—it would seem that the steam turbine centrifugal pumping unit must be conceded a place of primary importance in the field of water works engineering.

DISCUSSION

VICE-PRESIDENT LEISEN (in the chair): It is unfortunate that this paper either in full or in abstract form was not sent out before the convention so that members might have had a better opportunity to discuss it more intelligently. We will be glad to have such discussion as is possible under the circumstances.

MR. J. N. CHESTER: With regard to this subject it is well sometimes to have opinions on the records in a manner that they may not be misconstrued and used as arguments where they do not apply; and if in his discussion of this paper the speaker seems overprejudiced —which he hopes will not be the case, because this type of pump has its place—let him state that in the last twelve years his pump installations have numbered over one hundred, and about 25 per cent of same have been centrifugal; so you will see that the speaker is not wholly opposed to the centrifugal pump. But this paper taken abstractedly or if not interpreted intelligently may work great harm to intending purchasers of pumping machinery. However, this has been cared for and guarded against by the author of the paper when he states that the figures given are applicable to uniform load conditions only.

Now, gentlemen, during the convention of this association held at Washington the speaker gave to this body a tabulation of the plants that were then being operated under his direction, numbering some thirty-six or thirty-seven wherein he showed a comparison of the rated capacity of the pumps and the capacity utilized annually. He also showed the percentage of those water works that were direct and standpipe service, and the percentage of those that were reservoir.

The figures shown in the proceedings of our Washington convention are taken from plants stretching from the Atlantic, through eighteen different states, to the Rocky Mountains; from Merrill, Wis., to Shreveport, La., and Meridian, Miss., on the South. Let me also say that direct pressure permitted us to use only 40 per cent of the capacity of the pump that did the work. We divided the pumps into class *A* and class *B*. *A* was the economical pump and did 90 per cent of the work. At the reservoir plants our *A* pumps were able to deliver 60 per cent of their capacity. That is not a uniform load. Now the head varied with the load in many cases. Of course there are conditions under which you must change the head.

The pump under discussion here, the turbocentrifugal pump, is

applicable only when you have reservoir service, in the economies stated on these charts, for only when you have reservoir service can you get uniform load conditions, i.e., uniform head, and uniform quantity per minute.

Seventy-five per cent of the water works with which the speaker has come in contact over this country are direct pressure systems. Those conditions do not exist in the mountains of Pennsylvania where he lives nor the Appalachian or Rocky Mountains, nor along the bluffs of the rivers; but a large proportion of you come from the western prairies where there is not a hill high enough on which to build a standpipe to say nothing of a reservoir, so you cannot get uniform load conditions, and consequently these figures are not applicable to your service taking the conditions as they ordinarily exist. Suppose as at Erie, Pa., we have a service reservoir and must pump from a lake into a settling basin, would you tell us that was a uniform condition? Suppose our intake runs out $3\frac{1}{2}$ miles into the lake and the difference between the minimum and maximum head to which we must subject our pumps under the different conditions amounted to 14 feet, the initial or constitutional head being only 22 feet. We then have a variation of 50 per cent, and we have not uniform load conditions. Our settling basin is but 3,000,000 gallons capacity, and we can use only the first foot or two. All of which makes a very unfavorable condition for a centrifugal pump.

How many of you can supply uniform load conditions? It is fair to mention that the figures in the paper we have seen here are based on uniform load conditions absolutely, or presume pumping out of a river into a large settling basin or reservoir. It may be that had the speaker been the engineer under those conditions he would have selected that type of machine. The speaker is glad to see this type of machine being developed under conditions where we can put the turbine up above the high water and pump down below. That is a thing he has long sought, long prayed for and long been refused, and he is glad that Mr. Leisen has been able to persuade somebody to develop it in that way.

The speaker believes there are others here who are going to discuss this paper and probably bring out some matters that they can touch upon more clearly than he has. The speaker had a copy of this paper but not as read. He found that the first charts there were based on a 110,000,000 duty for an 8,000,000 gallon turbocentrifugal, and 150,000,000 duty for the vertical triple crank and flywheel. It is the speaker's opinion that the plant conditions that would permit a

110,000,000 duty on the turbocentrifugal in the light of today's developments would permit a 180,000,000 in the crank and flywheel; so he believes there is a discrepancy in that if you are going to allow one at 110,000,000 you should allow 180,000,000 for the other.

Let the speaker call your attention further to the fact that these figures are based on Mr. Hague's cost of reciprocating units. Now the speaker does not think it is fair to use one man's data for one thing and another man's for another. Figures like these involve the personal equation. If Mr. Hague's figures are fair for one part then Mr. Hague's figures and conclusions should be maintained clear through. Not long after Mr. Hague published that paper which was printed in our proceedings he wrote another paper for the American Society of Civil Engineers, in which he expressed his positive conclusion that the centrifugal pump was not in the race at all. He used his own figures to make the comparison. The author of this paper has used Mr. Hague's figures to support his conclusions on one side, and his own figures on the other. The speaker does not think that that is fair, because there is a personal equation in a comparison of that kind which even the most sublimely honest of us cannot eliminate.

The speaker only wishes that Mr. Beyer's paper had begun for its range down at about 2,000,000 gallons. He wishes also that it had begun the head at about 20 feet, then we could have included filter pumps. There is where we lack in economy, raising water 20, 30 or 40 feet high. There is where the centrifugal pump usually appeals to us to save on first cost; but unfortunately in small units it is not at all economical.

The speaker has given this matter a great deal of study. Most of you know that he has spent part of his life in the pump business, one part producing and installing, and another in operating. He is speaking to you from each standpoint, and is going to be fair to you and say that he never spent any of his life in the centrifugal pump business, but has in the direct acting and rotating or crank and flywheel production. But he has bought, installed and operated many centrifugals, and has made comparisons of weekly, monthly and yearly fuel bills, and believes he is familiar with their capabilities.

The speaker believes the centrifugal pump has made great advancement. He does not believe it has reached the stage of improvement that the author of this paper claims for it. He believes it will make greater strides in the next ten years. Anything that tends to reduce the cost of the operation of our plants and to increase our revenue, whether private or municipal, redounds to the benefit of everyone.

The turbocentrifugal pump is predicated on a high vacuum. You people that have to lift ten million or less against from 10 to 50 feet and who put in a pump of that kind and try to maintain a 26-inch vacuum, have a loss from leaks so great that when we try to maintain a vacuum of over 26 inches we must add so many refinements to our condensing apparatus and consume so much power to produce a high vacuum that we materially reduce the efficiency of the installation. Even if the unit is large we do not get in the turbo driven or engine driven centrifugal all the economies that we may with the direct acting or other types of reciprocating pump. The speaker believes this is going to be overcome in time. Every station has its own possibilities and limitations and is a problem by itself. There is a man up in Columbus who advertises a medicine called Peruna which he claims cures all diseases. Now there may be some things that Peruna will cure, but they are a mighty small per cent. And in like manner there are a great many services for which centrifugal pumps are the best; but they do not approximate anything like the percentage that the sanguine author of this paper claims, and is honest in expressing to you that they do. He advocates large units. He gets away from water works service and talks about electrical stations where if you are not consuming the power drops off; but in our water works engines you know it does not. Therefore we believe that a comparison between the two characters of service, water works and electrical, is misleading unless it is analyzed.

Again, large units are going contrary to that old proverb, "don't put all your eggs in one basket."

It is not the larger cities that are represented here as a majority, they are only a small per cent of our attendance, and the speaker is talking to the large per cent and not the smaller per cent. In the smaller cities you cannot install 40,000,000 or 50,000,000 gallon units without putting all your eggs in one basket. If you did and one unit was down and out you would be in trouble; and if you duplicate such large units you are running up the investment. The speaker always advocates a number of smaller units in water works practice as preferable to putting in fewer larger ones. It insures safety, which should be the controlling principle in water works operation.

Now in the copy of the paper to which the speaker had access, it was stated that the foundation cost of a certain size vertical triple expansion crank and flywheel pump had been $10,000. We are putting in a 20,000,000 gallon vertical triple expansion crank and flywheel engine where the foundation cost would not run much over

$1000. Both cases are exceptions and should not be put in the place of the rule, nor is it fair to quote the exception on one side against the rule on the other.

In conclusion let the speaker emphasize that the centrifugal pump has its own field; this is one of the types that we can welcome and use; and when it is separated from its motor and the motor turned on end for low service work along our rivers and the pump placed down in the bottom of the pit, it has reached a stage, as shown to us in the Louisville station, that is an admirable one and to be commended. The speaker only hopes that with such a long step forward its improvement in economy will continue until it will not be limited by 25 per cent or 75 per cent, or any other per cent, but that it can justly stand in fair comparison with or above the other types.

Mr. L. E. Strothman: This paper deals with a subject in which the speaker is directly interested, and although he did not intend to take part in the discussion of this paper, still he feels that the arguments upon which the cost of the two types of pumps, and their cost of operation, are based are so far in error that he believes these inaccuracies should be brought to your notice. Mr. Chester has called attention to some of these and the speaker proposes to amplify some of his contentions and add to his list of objections.

We have often heard it stated by backwoods philosophers "Figgers don't lie, and that the only reason why they don't lie is because they can't talk." If the figures used in the three tables which have been shown you had the power of speech, he is sure that they would protest violently.

The company with which the speaker has the honor to be associated builds all types of pumps and pumping engines, consequently, they are not prejudiced in favor of either the centrifugal or the crank and flywheel types of pumping engines and he is, therefore, in a position to point out the merits or weaknesses of either type without any prejudice.

The cost of triple expansion, crank and flywheel pumping engines as given in this paper and in the tables which it contains, is predicated on the approximate figures given by Mr. Charles A. Hague in a paper presented before the American Society of Civil Engineers in May, 1911. Mr. Chester has brought to your attention the inaccuracy of basing a comparison upon these general figures and the speaker is sure that Mr. Hague, for whose opinion he has the highest regard, wrote his paper with the idea of giving general information for the

assistance and guidance of other engineers and had no intention of having these figures adopted as representing the actual cost of vertical triple expansion pumping engines ranging in capacity from 8,000,000 gallons daily to 40,000,000 gallons daily. In fact, he states positively that each installation requires its own special treatment and study.

The speaker is sure that we would all be pleased if it were possible to prepare accurate data on the cost of vertical triple expansion pumping engines based merely on the capacity in gallons per twenty-four hours. He has had occasion to give this matter careful study for the last six or seven years and has often wished for some such data in order that he could tell a prospective purchaser exactly what a certain size machine would cost without going to the trouble of preparing a detailed estimate. So far he has seen no such data which is reliable, and believes that the nearest approach to this is in basing the cost of the engine on the water horse power of the machine and plotting curves with the water horse power as abscissa and the cost per water horse power as ordinates. By the use of this method it is possible by plotting a great number of curves to arrive at some general idea as to the cost of this type of pumping engine, although this varies from $70 per water horse power to approximately $230 per water horse power. The speaker has gone into this matter at some length to show you that any constant use for an engine having a capacity of 8,000,000 gallons would necessarily be entirely wrong for an engine having a daily capacity of 40,000,000 gallons per twenty-four hours.

The question of the cost of foundations has also been touched upon in this paper. Both of the types of pumps under discussion require foundations and this is more a matter of local building construction than the size of the machine. In the self contained vertical triple expansion pumping engine, the whole engine is entirely superimposed upon the water end and the foundations are very much nearer the same area as the area required by a turbine driven centrifugal pump with its condensing apparatus than one would judge at the first glance.

Relative to the question of constant load conditions which Mr. Chester has also touched upon, the speaker wants to repeat what he says, viz., that constant load conditions mean constant head, constant speed and constant capacity. Up to the present time, the most convenient method of comparing the total operating cost of the two types of machines under discussion has been to assume that both machines run at their point of maximum economy. This is a condition which does not obtain in actual practice and is always unreasonably in favor of the turbine driven centrifugal pump.

If we expressed the duty which is developed by a vertical triple expansion pumping engine when running under normal conditions as 100 per cent we can state the efficiency of the unit when running at half speed in per cent of the normal. The vertical crank and flywheel pumping engine when running at one-half speed and delivering one-half its rated capacity against the normal head will develop a duty only $5\frac{1}{2}$ or 6 per cent less than that which is developed under normal conditions. The steam turbine driven centrifugal pump is not so efficient at low rates of pumpage. In fact, you will find that the duty at half capacity with constant head would be only about 76 per cent of the normal. Taking into account the fact that most pumping engines run at a point somewhere between one-ha'f and three fourths capacity, you will see that the vertical crank and flywheel pump has an advantage which is not apparent at the first glance.

Most of the pumping engine installations in this country today contemplate pumping water directly into the mains and not into a reservoir. In addition to this, cities that at present have reservoirs are rapidly coming to the direct pumping system and are no longer using their old reservoirs for the purpose of establishing constant load conditions. The preceding statement is to disprove that the high economies attained by the crank and flywheel pumping engines are due to the constant conditions under which they operate. In any of the direct pumping systems, the friction loss increases in the ratio of the square of the velocity through the distributing system with an increase or decrease in capacity. This condition is very unfavorable for the use of steam turbine driven centrifugal pumps.

Steam turbine driven centrifugal pumps for water works conditions generally require that a gear drive be employed between the steam turbine and the pump. In order to obtain the high efficiency which is synonymous with high speed of the turbine and at the same time to construct a pump of normal proportions for the head against which it operates it is necessary to transmit the high turbine speed through a set of gears to the lower speed pump. The speaker believes the use of reduction gears is not an advantage, although it has been solved in quite a satisfactory manner by some builders.

Referring to the tables which accompany this paper, more especially to table 3 which bases the comparison of annual operating cost on a capacity of 40,000,000 gallons daily against 350 feet head, the speaker wishes to state that the size of a vertical triple expansion pumping engine is limited by the piston speed at which it operates, and this

limitation would preclude the building of a vertical triple expansion pumping engine of this h.p. In any form of reciprocating pumping engine in which the piston in the steam cylinder is directly connected to the water plungers, the plunger speed is limited by the rapidity by which the water can follow the plunger. Consequently, with a high suction lift it is necessary to employ low piston speeds. The accepted piston speed for pumping engines of this type lies somewhere between 200 and 300 feet per minute with automatic rubber pump valves, although this speed has been exceeded by the use of mechanically closed annular ring metallic valves of the Riedler type. The modern tendency, however, is away from the high piston speed and positively operated water valve on account of the higher expense of producing a pump of this type. We can, therefore, assume that good practice in the construction of vertical triple expansion pumping engines corresponds with a plunger speed not exceeding 250 feet per minute. Taking this as a basis and adopting any reasonable steam pressure, say as high as 180 pounds per square inch, the size of the machine is limited by the size of the low pressure cylinder and this limits the horse power to somewhere between 1200 and 1300 indicated horse power. Even with this horse power the low pressure cylinder becomes 110 inches in diameter and with this size of low pressure cylinder it means that a stroke of 66 or 72 inches is necessary, resulting in a large, unwieldy machine which is very expensive to build. The speaker does not believe any one would countenance the building of a vertical triple expansion crank and flywheel pumping engine for 2100 h.p. as indicated in tabulation "C." This last tabulation, therefore, cannot be considered, as it is based upon a size and type of machine which is not practicable to build either in this country or Europe.

The speaker knows he is running into a hornet's nest in making the following statement, but in this he is emulating Mr. Chester:

The first table indicates that with coal costing less than $2.91 per ton, the centrifugal pump is the one to install for a capacity of 8,000,000 gallons daily against 350 feet head. Table 2 indicates that fuel must cost almost $4 a ton before the vertical triple expansion type of pumping engine can be considered. Although table 3 shows that coal must cost approximately $8 a ton before the vertical triple can be considered, we will dismiss this table for reasons previously given.

The speaker knows of no water works plants in this country where they pay such unreasonable prices for coal. In any city in the United States of large population the price paid for coal averages

between $1.10 and $2.60 per ton of 2000 pounds, delivered in the station, and this coal is of a quality that contains all the way from 10,000 B.t.u. to 14,500 B.t.u. per pound.

The city of Chicago pays $1.28 per ton of 2000 pounds delivered in the station for Illinois screened coal containing from 9600 to 10,500 B.t.u. per pound.

The speaker is informed by Mr. Leisen that the Louisville Water Company pays $1.15 per ton for coal delivered in the pumping station. The cost of coal is being brought directly to your notice in this connection to show that a great many able engineers in this country have decided that the crank and flywheel triple expansion pumping engine was the most advisable type to use, with coal costing below $2 per ton.

The speaker knows of no installation that has been made in this country during the last five or six years in which the engineer in charge of the preparation of the specifications did not give the steam turbine driven centrifugal type of pumping engine very serious consideration. It has been his experience that the men buying this class of machinery know practically as much about it as the builders, and he is satisfied that there have been no serious engineering blunders made in the installation of vertical triple expansion pumping engines during the past few years.

The 40,000,000 gallon pumping engine described in the third table, known as table "C," is predicated upon the belief that the size of pumping machinery will increase somewhat along the same lines as the increase in size of power generating units.

In conclusion, the speaker wishes to draw your attention to the greatest injustice in this comparison of the two types of pumps as given in Mr. Beyer's paper, viz., that of the duties which will be developed by the two types of machines. Assuming that the duties as given in tables 1, 2 and 3 for the steam turbine driven centrifugals are correct, he wishes to state that under conditions where a steam turbine driven centrifugal pump will develop a duty of 105,000,000 foot pounds, a pump of the vertical triple expansion type will develop a duty of 175,000,000 instead of 150,000,000 foot pounds as stated.

Next refer to table 2. Under the same steam conditions, with the centrifugal developing 120,000,000 foot pounds duty, a vertical triple expansion crank and flywheel pumping engine will develop 195,000,000 instead of 165,000,000 foot pounds.

The speaker has previously stated that the figures in table 3 should not be given any serious consideration, but he wishes to point out

that the duty of the vertical triple expansion engine would be practically 300,000,000 foot pounds in place of the 223,000,000, as stated.

He further wishes to state that had this paper been as unjustly favorable to the vertical triple expansion type of pump as it is to the turbine driven centrifugal, he would have protested in favor of the centrifugal type of pumping engine if he thought that the basis of comparison was not proper.

Mr. Edward S. Cole: The question of efficiency in a centrifugal pump is of great importance, but the purchaser is more interested in maintaining high efficiency throughout the life of the machine than in securing it merely at the acceptance test.

The speaker has had occasion to make a number of tests of centrifugal pumps in actual operation such as, for example, the seven 40,000,000 gallon centrifugal pumps at the Torresdale filter plant at Philadelphia, and he realizes the difficulty not only of securing full contract efficiency when pumps are new but also the difficulty of maintaining the same high efficiency after a period of use.

The cost analysis and financial balance upon which the type of pump is decided presupposes the maintenance of the assumed efficiencies throughout a long period. If this anticipation is not fulfilled it is easy to see that the conditions upon which we have predicated the type of pump have totally changed, and the speaker would urge the purchasers of centrifugal pumps to consider what average operating efficiency may be expected after a period of use and not merely base their decision upon maximum efficiency of test conditions. As a case in point, the Buffalo water works operates large electrically driven centrifugal pumps whose impellers have repeatedly shown remarkable deterioration. After a few months' service these pumps show a falling off of capacity and efficiency.

Mr. Lyon said to the speaker in Buffalo, this winter after examining a piece of a bronze impeller blade that had been taken out of one of his large centrifugal pumps, that the deterioration of which we have all heard starts after a few weeks' service, and develops to a sufficient degree to impair the efficiency within two months.

Mr. Henry L. Lyon: We have all sorts of trouble with the impellers giving out after about a year's use and causing the efficiency to run down very materially. Upon taking the machine apart and looking at the impellers we found they were very badly eaten up. We attributed it to the fact that at times we have some fine sand in the

water, and the rapid revolutions caused the sand to have a sand blast effect, wearing out the impeller blades to such an extent that the efficiency dropped from 68 per cent down to 40 per cent.

MR. H. F. DUNHAM: Mr. President: What you have said with respect to the failure to provide members of the association with advance copies of this paper is appreciated. It is an important paper and the members would have been glad of an opportunity to peruse it. Many do not like to discuss a paper containing so many figures without something more definite than newspaper references. If some way could be provided by which an advance or official copy should reach the members it would add to the interest in the discussion and be helpful to the association in a general way.

One point has not been considered in the discussion. If a certain result is to be accomplished by two methods where one method requires a small investment and the other a very much larger investment, it is only good business to ascertain if possible, what relation the added expenditure bears to maintenance, depreciation and the length of life of the machinery or installation. Where the investment itself is small 10 or 15 per cent of that amount is also small while the same percentage of the larger investment becomes an important item. Now if the large investment is made for the purpose of reducing the percentage for maintenance and depreciation as well as for economy in operation and if that object is successfully accomplished the application of the same percentage in the two cases may lead to great inequity. Good triple expansion installations have been operated for many years. The cost of repairs and general facts about maintenance and depreciation are matters of record and should find a place in the discussion of this paper. If an average of many records should prove to be below the assumed 10 per cent there would be evidence of reasoning from wrong premises unless experience indicated that substantially the same advantage pertained to machinery of the new and cheaper kind. Thus there are questions of fact involved that ought to be carefully considered before all of the general conclusions reached in this paper can be accepted.

MR. J. S. FULTON: The speaker has been associated with Mr. Beyer in the preparation of this paper. At the present moment he rather feels as if there had been four of us talking along the same lines and in favor of the points brought out in Mr. Beyer's paper. In contradiction to the gentlemen who have just spoken, the constant head

and constant quantity condition is the best basis of comparison though it favors the reciprocating pump rather than the turbine unit.

If you take the centrifugal pump and let it operate at capacities less than that for which it is designed at constant head, it will have a higher comparative efficiency than the reciprocating pump, which must change its speed in direct proportion to the quantity, while the centrifugal will deliver a reduced quantity with a very small speed change. This is due to the fact that with the centrifugal pump the quantity varies directly with the speed and the head as the square of the speed, and for a constant head approximately 5 per cent variation in speed will make a difference of 15 per cent variation in capacity. The speaker has one illustration in mind, a unit designed for 10,000,000 gallons of water per day that gave on test a duty of 103,000,000 foot pounds of work per 1000 pounds of dry steam, and a duty of 93,000,000 foot pounds of work when delivering at the rate of only 7,000,000 gallons of water per day at the same head, thus a 30 per cent capacity change is effected by a change in duty of less than 10 per cent.

The speaker believes this point however is one that is open to statements on one side or the other, since as far as he knows there are no conclusive figures published anywhere on reciprocating units tested at less than their full capacity.

We did not use one class of figures in estimating the cost of one unit, and another class in estimating the cost of another. While we gave figures from a paper presented before the American Society of Civil Engineers by Mr. Hague, the prices we used for reciprocating units were made up from the various estimates that have been received by different cities, and are to the best of our knowledge, accurate, as stated.

The question of low head centrifugal pump operating with high duty, with variable capacity and variable head is one that is easily answered by reference to existing installations. The speaker believes Mr. Shaw of Lancaster, Pennsylvania, has been operating a low head pump for perhaps twelve years, and has found no change in duty during that period. (Mr. Shaw was referred to at this point and corroborated the statement.) At the Torresdale plant, city of Philadelphia, there is in operation a 50,000,000 gallon turbine driven centrifugal pumping unit the head of which varies from 44 to 52 feet during twenty-four hours, due to the tidal action in the Delaware River. This unit has a station duty of over 100,000,000 foot pounds of work per 1000 pounds of steam.

Question was raised by the first gentleman speaking on the vacuum we have specified as being too high for condensing operation, and in answer the speaker would say that in water works service where you have a practically unlimited quantity of water, there is no reason why you should not go after a 29-inch vacuum for the turbine, while on the same basis a somewhat lower vacuum is best for the reciprocating unit. Though stuffing box troubles develop on the reciprocating units due to the alternate push and pull of the piston rod, the real reasons compelling the avoidance of the high vacuua are the tremendous increase in steam volumes requiring prohibitive cylinder dimensions and the greater range of temperatures in the cylinders with consequently greater losses from condensation.

The question of high vacuum is a simple one and the speaker is sure any condenser man present will agree to build a condenser for as high a vacuum as you specify, and care to spend the money for.

In European practice they carry a higher vacuum and a higher superheat than is usual in American practice on larger units, so perhaps they have a little the advantage of us in turbine construction because of the better economies they can obtain due to better steam conditions.

As regards the statement that there are few places where a unit of this size could be installed, would say that since we have instances in this country where units of from ten to 25,000 kw. capacity are installed in plants having a 40 per cent load factor, there is no reason why a 40,000,000 gallon pumping unit should not be installed in a water works using between 100,000,000 and 300,000,000 gallons per day.

The speaker is not positive, but he believes there is in existence a 30,000,000 gallon reciprocating unit at Knoxville, Tennessee.[1]

MR. L. E. STROTHMAN: There is a 30,000,000 unit in Boston that has been running for about twelve years, but it is not under 300-foot head.

MR. J. S. FULTON: There is one at Nashville under a high head.

On the question of a coal cost of $8.80 per ton, and the gentleman's statement that there are only three cities in the United States that he

[1] He has since found that this is a 20,200,000 gallon unit vertical triple expansion, installed in Nashville, Tennessee, according to *Engineering News* of March 10, 1910, working against a head of 385 feet, having a duty of 184,700,000 foot pounds for a 29-inch vacuum.

positively knows of where the coal costs that much, the argument is that when you get large capacities at high heads, and where you say it is impossible to build a triple or probably a quadruple or a quintuple, or even a sextuple expansion pumping engine then it belongs absolutely to the centrifugal pump, whether the driving power is electrical or steam. That is the particular point we wanted to emphasize.

If you want to take care of 100,000,000 gallons per day against a head of say 575 feet, you can do it with a turbine driven centrifugal pump; and as this gentleman said, you cannot do it for services of this magnitude with a reciprocating pump. That is the reason that tabulation "C" was included in this paper.

As regards the question of foundation cost the speaker will agree with the gentleman who has just spoken that there is very little difference in the floor area that they take up in a plant, but this is not the condition that determines the cost of foundations. The centrifugal unit will have a low pressure per square foot and since there are no reversals of direction of rotation that require mass in the foundation, small volume, while on the other hand the reciprocating unit must have this large mass, and in consequence it is its greater pressure per square foot that requires spread footing or possibly the use of piles in poor soil. It would be possible for instance to put the centrifugal unit on a float or pontoon and the operation would be satisfactory as long as the pipe joints were kept tight.

In the particular case of the 20,000,000 gallon unit the cost of which was $120,000 there was a foundation cost of approximately $18,000 which could have been very materially reduced had the unit been centrifugal.

There is one reciprocating pump mentioned here that had only $1000 worth of foundation for a 20,000,000 gallon unit, which condition was due to the presence of bed rock at the proper elevation, and for which condition there would be practically no difference in the cost of the two types of foundations.

Since the ordinary installation does not have the bed rock so fortunately located, it is necessary to bring in the foundation cost in the comparison of the two types.

Mr. E. E. Davis: The speaker is using centrifugal pumps at Richmond, driven by water power. He was particularly anxious to learn after those pumps were installed what would be the difference in their performance under a 14-inch vacuum with a head of 4 feet; so he ran them on a vacuum of 12 to 14 inches which gave a result of

4,000,000 gallons in twenty-four hours. When the head was at an average of from $2\frac{1}{2}$ feet above the pump to 8 feet above, he found that all of the pumps were pumping between four and five million instead of four million. So he was much pleased with the centrifugal pumps. They are giving him admirable service.

Mr. Alexander Potter: The speaker would like to ask Mr. Chester whether he understood him to state that the cost of the foundation for a 20,000,000 gallon pump was as a rule $1000, that that was the rule and not the exception?

Mr. J. N. Chester: It was quoted as an exception. The statement was quoted in this paper and might have been accepted as the rule because it was not stated that it was the exception. The speaker stated that it was the exception and simply gave the other extreme.

Mr. Alexander Potter: I understood you to say that that cost of $1000 is an exceptionally low cost.

Mr. J. N. Chester: It is an exceptionally low cost, just as $10,000 is an exceptionally high cost.

Mr. C. B. Salmon: The figures that have been given have mainly applied to large installations. The speaker would like a little information about the smaller installations that are in the majority so far as numbers are concerned. He would like to know if a centrifugal pump can be made to keep its suction on 15, 20 or 25 vacuum constantly? He has had some experience in Illinois, Wisconsin, Kansas and Virginia, with both of these types of pumps; and the centrifugal pump for raising water into the filters can be certainly relied upon when the lift is not over 20 feet, and he believes under short heads it is the most economical type; but when it comes to a one and two-stage centrifugal pump for fire purposes we have had trouble in keeping our suction, and have had to resort to mechanical means in order to keep air out of the pump which sometimes shuts off the suction. Now the speaker would like to know if the centrifugal people are prepared to guarantee the suction on their pumps in these smaller pumping units of from two to four million, in both one and two stage, and on 50 to 125 foot head.

Mr. J. P. Berry: The speaker is one of the little fellows. We have three centrifugal pumps in our water plant. They will handle

about 1,000,000 gallons a day; the lift is about 75 feet. Two pumps are three-stage, and one is five-stage. We have had one in operation for eight years, and after operating that for three years we bought another one, and have recently installed the third one. They have certainly given us satisfaction or we would not have bought them and put them in. We do not pump against any head, we just deliver into a reservoir. One of the pumps is motor driven, the motor being 40 h.p. The last one we installed is direct connected to a 75 h.p. motor arranged for two speeds, 850 r.p.m. and 1150 r.p.m. The speaker cannot tell you the exact efficiency because we have not gone into that particularly; but we pay 2 cents per kilowatt up to $200 a month, and when we run over $200 a month the rate is reduced to $1\frac{1}{2}$ cents per kilowatt. We are putting about 1,000,000 gallons a day into the reservoir, which is about the capacity of the pumps, at a cost of about $300 a month. We have no expense except for the power, the engineers who take care of the plant go to the centrifugal pumps three or four times a day and oil them. After the pumps have run a year we take them out and overhaul them. One of them ran twenty-four months without having anything done to it. They have been very little expense to us as far as upkeep is concerned, and we like them very much.

Mr. J. N. Chester: Can you tell what your percentage of fuel bill under low service is as compared with the high service?

Mr. J. P. Berry: I cannot tell that, because we have no high service, we simply pump from the well into the reservoir, then we pump out of the reservoir into the town with a reciprocating engine. It costs us much more to take water out of the well and deliver it to the reservoir than it does to take it out of the reservoir and deliver it to our people. Our lift is about 75 feet on the turbine pump. On the reciprocating our engine is on a level with the pump and there is no lift, but we pump against a domestic pressure of 60 pounds.

Mr. W. F. Wilcox: The speaker had occasion not long ago to go through the plant at Columbus, Ga. They pump out of the river into a settling basin by electricity against 94 pounds pressure. He has a detailed statement for the past five years showing what they paid for current for each pump and what the output was. Both the input and output was through a meter. He will be glad to furnish the figures to anyone interested.

PROGRESS IN ADOPTION OF THE NATIONAL STANDARD HOSE COUPLING AND HYDRANT FITTINGS FOR PUBLIC FIRE SERVICE

By F. M. Griswold

When this proposition was first presented for your consideration the committee which the writer represents held data relating to coupling dimensions in only about 1600 separate localities in this country. Since that time it has created a card index record covering data in some 3133 towns and cities in the United States and the Dominion of Canada; this work has been accomplished through persistent effort, and at considerable cost in money as well as in the expenditure of time and patience.

This record is believed to be as nearly accurate as can be expected in a work of this character and magnitude; the data which it contains having been very carefully compiled from ten separate sources of information, including signed statements from fire chiefs and water work managers, transcripts from the official records of many manufacturers of hydrants, hose or other fire department apparatus, supplemented by reports made by the engineers employed by the various insurance inspection organizations.

Analysis of the data shown in this record, based upon actual results accomplished in the conversion of non-standard couplings to safely interchange with the established standard, demonstrated that approximately 80 per cent of the couplings listed are either of standard dimensions or may readily be so modified as to conform to same, without necessity for replacement, while the cost of conversion or replacement has been demonstrated to be so small as to be almost negligible in the accomplishment of this very essential change from chaos to uniformity in public fire fighting utilities.

In further evidence of progress in this work, the record shows 73 cities or towns in which the national standard has been put into service as a result of this "appeal to reason;" seven of these installations including the complete substitution of national standard hose couplings and hydrant nipples in place of previously prevailing non-standard devices.

Notable among these being the city of St. Louis, Mo., the pioneer in the active promotion of standardization, in which city over 11,000 hydrant outlets and the couplings on many thousands of feet of fire hose were changed from a so-called "bastard" 6-thread to the standard, all of the work being done by city employees, at an average net cost of one dollar per hose coupling, and of $2.82 per hydrant outlet, the latter being principally of 4½-inch steamer suction type, each of which was laboriously chipped out by use of a cold chisel.

Closely following this action by St. Louis, the city of East St. Louis which lies on the opposite shore of the river, in Illinois, brought its equipment into conformity with that of the larger city upon which it must call for aid in time of threatening disaster.

During the winter of 1910–1911 the city of Springfield, Mass., discarded the "universal clutch" coupling and substituted for it the national standard, changing over 1350 hydrants, some of which had four outlets, at the rate of from 50 to 100 outlet replacements per day, at an average net cost of $1 per outlet, giving credit for the old metal, sold at 9½ cents per pound, and excluding cost of labor performed by the regular force of water works employees. Couplings on 22,000 feet of hose were changed by department employees at a like net cost of $1 each.

It is interesting to note that this work at Springfield was carried out in the winter season, and that it was accomplished without accident by the use of surprisingly simple and expeditious methods, in that where hydrant nipples were leaded in, the use of a 6-pound sledge proved an efficient means for their removal, while in the case of screwed in nipples, an expanding wrench, entered from the out board end of the nipples engaged the operating lugs and permitted the easy removal of the device, while the 4½-inch leaded in suction nipples were melted out by the use of a plumber's gasolene blow-torch, at the rate of five minutes per operation. This practical and unique demonstration of "how to do it" is commended to your serious consideration.

Following this action at Springfield, the contiguous cities of Chicopee, Holyoke and West Springfield, each brought its equipment into conformity with the standard, at an expense probably no greater than was that of the change in Springfield.

Shreveport, La., replaced the old time "Feyh" coupling by installing the standard, but we have no data as to method of procedure, nor as to the cost of the operation.

In the cases of the 66 towns and cities which are known to have adapted non-standard couplings to interchange with the standard,

the work has been accomplished entirely by the regular force of public employees, and outside of the time used, the expense has been nominal, at most involving the cost of an adjustable tap and die, conforming to the pitch of the non-standard thread, by the use of which these couplings were so modified as to become readily interchangeable with the standard.

It will perhaps prove of interest to you to have cited some of the prominent cities and towns which have thus brought their equipment into harmony with the national standard. Atlanta, Ga., used both 7 and 7½-thread couplings for years without serious trouble from these differences, but now uses the standard only. Watertown, N. Y., in making the change to standard discovered that they had three different kinds of hydrant outlets, varying both in number of threads and in their outside dimensions, all of which have been made to conform to the standard without other cost "than the casting of a die," as stated by the chief of the fire department.

In addition to the above, the change to standard by modification of couplings in the following cities has been accomplished at so low a cost and with so little trouble, that those responsible for this evidence of progressive action have not considered it necessary to prominently exploit their good work.

Eufaula and Huntsville, Ala.; Enfield, New Britain and Norwich, Conn.; Moline, East Moline and Rock Island, Ill.; Elkhart and Hammond, Ind.; Davenport, Iowa; Brockton and Newburyport, Mass.; Battle Creek, Grand Rapids, Jackson, Lansing and Monroe, Mich.; Greenville and Jackson, Miss.; Carthage and Neosha, Mo.; New Brunswick and Trenton, N. J.; Binghamton, N. Y.; Columbus, Mansfield and Wilmington, Ohio; Columbia, S. C.; Jackson and Nashville, Tenn.; Brownsville, Port Arthur and Tyler, Texas; Bellows Falls, Vt.; Everett, Port Townsend, Seattle and Tacoma, Wash.; Cudahy, Manitowoc and Milwaukee, Wis.

The number could be materially enlarged by naming some 30 other towns of less prominence which are known to have brought their equipment into conformity with the standard, while from information not yet verified, it is believed that a number of other localities have taken like action. In addition to the above noted instances of adaptation, the record shows the installation of the standard in 122 localities not so listed at the date of the last issue of the record in 1911, and as in evidence of the widespread interest aroused in this important matter of standardization, it may be stated that one prominent concern, manufacturing fire hydrants, reports having filled orders for

hydrants under "national standard" specifications for some 46 separate towns and cities, included in which number may be named Montreal, Port Hope, Ste. Anne and St. Joseph in the Dominion of Canada, and the town of Abonito, in Porto Rico.

It is highly gratifying to be able to present to you this "report of progress," showing so much of accomplishment in a cause of such great public importance, and thus to place on record an accounting of our stewardship of the trust assigned to our care.

The advance indicated has not been attained without the expenditure of serious and persistent effort, exerted practically without support through concerted coöperation by most of the important organizations, which, having endorsed and adopted this standard as essential to widest benefit of the public welfare and safety, are at least impliedly obligated to forward its acceptance and installation within the municipalities under their jurisdiction, and it therefore appeals to the writer that the opportunity is present and the time is now ripe for the promotion of a closer spirit of coöperation by these influential bodies in forwarding to speedy accomplishment the general acceptance of this highly important standardization of public fire fighting facilities, and to this end let him hope that your association will take the lead in an effort to insure such coöperation, as to your honor, you have taken the lead in approval of the national standard hose couplings as a means whereby the present condition of chaos and inharmony may forever be eliminated in the matter of public fire extinguishing apparatus.

Now, having shown you at what little expense these needed changes may be secured, as evidenced by the practical experience indicated, let the writer again demonstrate to you the practicability of so modifying both a 7 or 8-thread coupling as to produce a perfectly reliable connection when a $7\frac{1}{2}$-thread female swivel is used as an intermediary or accommodator to complete the joint.

The technical explanation of this seeming mechanical anomaly, where either a 7 or 8-thread male screw may be made to serviceably fit a female swivel of $7\frac{1}{2}$-thread pitch, will be readily appreciated when we recall the fact that threads having a V-shaped section possess a peculiar and valuable property of adjustment in relation to the accommodation of other threads of like shape, but which do not exactly conform in pitch, and which can yet be made to fit closely enough for all practical purposes. The property in question being that which relates to the clearance between the threads, which quality is strikingly illustrated in making ordinary nuts, bolts, and

screw joints, where it is required and utilized to secure a practical fit in the joint without dependence upon absolute accuracy in workmanship.

Keeping in mind this peculiar and valuable property of the V-shaped thread in making a comparison of the differences of clearance between 7 and $7\frac{1}{2}$ and 8-thread pitch, it becomes evident that with a thread of 7 turns to the inch, the space or distance between the crests of the threads will be about 0.1428 of an inch, while in the case of the thread having $7\frac{1}{2}$ turns to the inch its crests will be 0.1333 of an inch apart, and that with 8 turns to the inch the crests will be 0.1250 of an inch apart; hence, in selecting this standard of $3\frac{1}{16}$-inch outside diameter, with $7\frac{1}{2}$ threads to the inch, it will be found that by reducing the diameter of the male end or increasing the diameter of the female ring or swivel by a fraction of an inch, the first crest of the modified male thread will fit into the valley of the $7\frac{1}{2}$-thread female ring, and that while in the progression of the spiral the following crests will not be exactly coincident with the corresponding valleys, the normal differences of clearance will be only 0.0083 of an inch for the 8-thread, and 0.0095 of an inch for the 7-thread, or in other words less than one-thousandth of an inch in either instance, while the reduction in diameter will be sufficient to prevent clashing of the inclined surfaces, and thus permit a fit with practically as good contact throughout the joint as if these modified threads were of the same pitch as that of the female ring into which they are entered.

With these facts before you, showing how cheaply and easily complete standardization may be secured, the proposition seems to have been robbed of its mystery and doubt, both as to cost and method of procedure, through the very simplicity of its means and accomplishment. No competent mechanic can offer a valid objection to the standard as specified, and it is not presented to your attention as a new or novel revelation in mechanic art; it is not patented, nor is it patentable; it is but a simple adoption of common present means toward the elimination of present indefensible conditions, which continually cry aloud for the abolition of the incompetence, ignorance and carelessness which now control the selection and installation of these vital public utilities, the standardization of which is of transcendent importance in the conservation of our created resources, and in the preservation of human life in jeopardy from fire.

Manufacturers of hydrants and other fire department apparatus, will hail with gladness the day when any order for such adjuncts could be safely executed by compliance with specifications demanding conformity to the "national standard."

Therefore, the writer appeals to you to abandon this comedy of chance, and enter into the realm of reason, to the end that by unity of action and persistent endeavor to firmly establish the introduction of this much needed reform in municipal practice in relation to necessary public fire fighting facilities. Let us prepare no more graves on the headstones of which can only be repeated the inscription, "Here lies Inconclusion."

LAYING WATER MAINS UNDER STREAMS OR HOW WE CROSSED TWO STREAMS WITH WARD PIPE AT ROME, GEORGIA

By M. L. Worrell

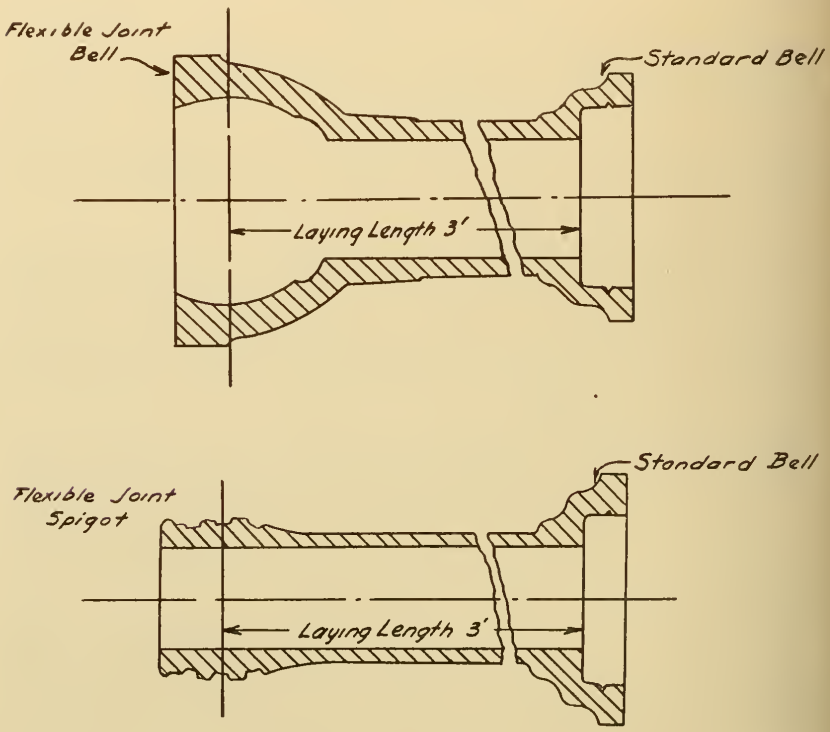
So far as the writer knows, the work of laying water mains under streams has not been the subject of a paper before the American Water Works Association for the past ten years. It has been thought, therefore, that a few words, descriptive of his own experience in that line, might prove interesting to the membership and to water works people in general.

The first work of this nature, in his experience, was accomplished while superintendent of public works at Rome, Ga., having in charge the water works, streets and sewers of that city during the three years beginning January 1, 1908. There were three crossings to construct, one through Silver Creek and two through the Etowah River at different points.

The creek was to be crossed near a highway or county bridge and it was deemed advisable to lay the pipe on the bottom of the creek, properly secured, rather than to suspend it from the bridge, or to lay it on the floor thereof, on account of the sudden rises and terrific floods the stream is forced to carry, at times, it being the drainage outlet of a large area of mountainous country.

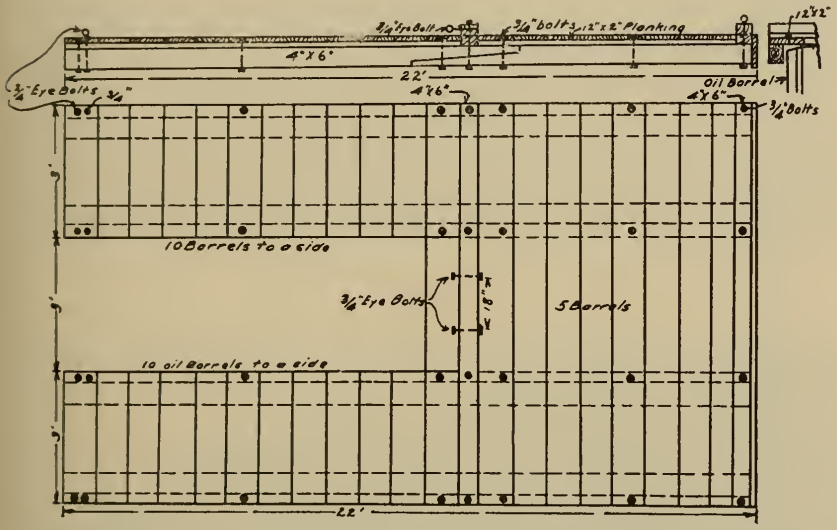
At the point to be crossed the creek was 60 feet wide between banks at street level, 40 feet wide at low water, and, at ordinary low water stage, 12 feet deep. Material used was cast iron made with John F. Ward's flexible joint, size 10 inches in diameter, weight about 87 pounds per foot or 1034 pounds per joint of 12 feet, costing 2 cents per pound, delivered in Rome and made by a prominent concern located in Philadelphia. The limit of deflection of this joint is said to be 15 degrees though we did not find it safe to use the limit, 12 degrees being, in our experience, safer. The pipe line of five joints, 12 feet each, was made up, or constructed, on a platform spanning the creek at the level of the street, then lowered by means of proper tackle into the stream, the two ends being kept clear of the water for later joining to the water mains on each side of the creek, and the submerged part being gradually lowered, thus allowing deflection, until it rested

on the bottom. The pattern of the Ward pipe bell and spigot being of different design from the ordinary cast iron pipe, the two were connected by short pieces designed by the consulting engineer, Mr. J. N. Hazlehurst, who was in responsible charge of both engineering and construction. Tracing of this design is attached to and made a part of this paper. After the Ward pipe was attached to the street main a test, hereinafter described, was made for leakage, this test revealing a loss of 28,000 gallons per day of twenty-four hours. This being



excessive a diver was sent into the water to ascertain the cause and exactly locate same, the examination revealing that the limit of safe deflection had been exceeded, causing three lead joints to leak very badly. We then detached the creek line from the main on each side of the creek, raised the entire line, recaulked all joints, partially filled the bottom of the creek with small boulders, using several cubic yards in securing a good foundation and in reducing the deflection to about 12 degrees, again lowered the pipe line into the creek and joined it to the regular main, when the next test showed only small

leakage of about 380 gallons per day. Later this joint was again caulked and the leakage reduced to quite a small quantity, about 150 gallons per day. The foundation made by the loose boulders was added to, the pipe being covered and otherwise made secure, since which time no trouble has been noted though many heavy rains have caused large floods to be thrown against it. This work was done in the month of September, 1908. The last test made by the speaker was in the month of December, 1910, both for leakage and to ascertain if the pipe had moved, even slightly, down stream. No movement was noted and the leakage had not increased. The cost of this work approximated $300, everything included, or $5 per lineal foot.



The first river crossing was at Second Avenue, north of the East Rome highway bridge spanning the Etowah River, the height of the banks being about 40 feet above low water. We prepared for this by providing the necessary wire cable, stretched from bank to bank, to which the trolleys for carrying the supply boat and pontoon raft were attached. The pontoon raft or boat, from which we were to lay the pipe in the river, was constructed, as shown in the tracing attached, and more particularly described as follows, to-wit: The flotation was provided by twenty-five empty oil barrels, lashed together with ½-inch manilla rope, the barrels being laid in three rows, head to head, row no. 1 having ten barrels, row no. 2 five and row no. 3 ten, the three rows being laid parallel thus leaving a "slot"

in the middle row, same being to the stern of the raft. The barrels having been so arranged a deck was built upon them, as shown in the detail, the material used being pine lumber 2 by 12 inches of the necessary length to cover the barrels as laid out, the barrels being secured under the deck by drop pieces or retaining "sleepers" enclosing the outfit, making a strong raft, extremely buoyant and practically impossible to sink or capsize. The carpenter work, when completed, leaving the "slot" ready for the purpose for which it was designed, that of laying the pipe through it. The woodwork was so left as to make it easy to transfer the "slot" from the rear to the front for purpose later described. Two trolleys, with the necessary tackle for operating the raft, were attached to the wire cable and secured to the raft, a supply boat, improvised from a river flat or ferryboat, was provided and attached to the wire cable and almost directly beneath it, this boat carrying extra lengths of pipe, pigs of lead, yarn, melting pot, etc. The pontoon boat carried nothing but a tripod made of 2-inch wrought iron pipe attached at flattened ends by a suitable bolt, supporting a triplex chain block, this being for handling the pipe in process of laying in the bed of the river. The completed outfit was propelled across the river by means of a lead or hand rope. The first joint was secured to a "dead-man" on the bank, by means of a heavy chain, the outfit pushed off, the bell of the pipe forward, the second joint fitted therein, the joint poured and caulked, outfit moved forward again with the next and each succeeding pipe until the shore across the stream had been reached. The "slot" was then moved forward, or to the front end of the boat by removing a part of the deck, which had been constructed for the purpose, removing the short row of five barrels to the stern, placing the movable portion of decking to the rear thus leaving the last joint of pipe ready for attachment to the forward shore of the river and to the ordinary 10-inch cast iron pipe. The short joints of pipe for joining the Ward pipe with the ordinary cast iron pipe were 3 feet in length, or made to lay 3 feet, and will be more easily understood by an examination of the cut (Fig. 1) accompanying this paper, one having the standard bell on one end and the flexible joint bell on the other and one with the standard bell and the flexible joint spigot.

After the operation of laying the river crossings was completed security was insured by anchoring or attaching two joints on each end of the river pipe to "dead-men" permanently constructed in the banks, heavy hog chains being used for the purpose. Before the

work of laying the pipe was begun the river bottom was sounded, it being found to consist of solid rock, slaty limestone, with three ledges running longitudinally, each ledge having practically the same elevation. These ledges were cut or notched and the pipe, while being laid, was fitted therein, the notches being made by blowing away a portion of the ledge with dynamite. These notches secured the pipe from deflection down-stream and provided safe anchorage for the pipe without the necessity of providing a channel in which to lay it. The length of this river crossing was 216 feet and the time required for preparation and actual laying was about six days. The writer has only two photographs left of his collection to show you, but they convey a clear idea of how the pipe laying outfit was operated and the gang doing the construction. We used the services of a construction superintendent, who also performed the duties of foreman, a straw boss or gang foreman and five able-bodied negro laborers and one water boy, the pipe laying cost being about 35 cents per foot. This particular job cost about $700.

We crossed under the same river, at Broad Street, with a 12-inch pipe, the river being somewhat wider and deeper, no notches in the rock having to be cut and no channel to be prepared, the cost of this job approximating $900. It required less time to prepare for and lay the last line on account of the experience gained in construction of the first.

The work was done, as already stated, in the month of September, 1908, when the river was at the lowest stage known for years, this being somewhat in our favor though not necessarily so as it could have been too low. We had no accidents and nothing of an untoward nature marred the work of construction. The work was and still is entirely satisfactory and by the means adopted the board of public works of Rome, Ga., and in reality the people of that progressive little city, were saved upward of $3000, a water works contractor of Georgia, who had done similar work in Rome, though pursuing a different method, offering to do the work, no material included, for $3500, the cost of material being approximately $1200 including equipment.

On each side of the streams through which the pipes were laid we placed valves for cutting off the crossings in case of emergency and it was by means of by-passing these valves that we were enabled to make the tests heretofore mentioned. One of the valves at each crossing was enclosed in a telephone or coffin-shaped manhole, in which manhole we tapped the main on each side of the valve, the inlet tap being $\frac{3}{4}$-inch and the outlet tap being one inch. Lead connec-

tions, properly equipped for the purpose, were attached to the taps and the other ends connected to a 1-inch meter, so sensitive that it would register a gnat's breath, thus by-passing the valve which, along with the other across the stream, was shut off, the water turned on at the $\frac{3}{4}$-inch inlet tap, slowly and as slowly let out at the outlet one inch tap. As soon as the meter and outlet connection had filled, the meter ceased to operate, apparently showing that we had no leaks in the first river crossing. Not entirely satisfied with this we removed the meter, blew through it to show whether it was "stuck" or not, replaced it, repeated the operation of by-passing and experienced the same result. Both river crossings showed the same results at the first and all subsequent trials, made quarterly during the term of the writers engagement at Rome, three years. The creek crossing did not get worse. The writer prepared for and made similar tests of the crossings already laid, three in number, at other points, but they were not so satisfactory, though the leakage observed would not justify reconstruction of the old lines.

DISCUSSION

Mr. John A. Kienle: A question the speaker wishes to bring up is principally one that affects the design of submerged lines. We have had some experiences in connection with repairing submerged lines. From what the writer has said the speaker judges that Ward joint pipe has been used exclusively. He would like to ask whether the flange knuckles of the Ward joint have been used anywhere along the submerged line?

Mr. M. L. Worrell: None at all.

Mr. John A. Kienle: In connection with that the speaker wishes to call the attention of the association to the fact that considerable danger may arise from using no flange joints in such a line as described by Mr. Worrell. Our experience at Wilmington shows the necessity of having some available means of repairing a submerged line in case of damage to it, either by a barge anchoring at or near the pipe and settling on the line and breaking it, or through being struck by a steam dredge in deepening of the channel.

At Wilmington last fall an increased depth of channel was required by the United States government and they sent a dredge to take out several feet on the bottom. We have a twelve-inch submerged line

approximately 350 feet long in the river. The dredge used was of the suction type, having a cutter head, and in dredging this cutter head struck the top of the pipe and broke out a section possibly 3 feet long and of the diameter of the pipe. A crack extended along the pipe approximately 18 inches. Being exclusively Ward joint pipe it was a difficult matter to repair it. There being no flange joints it was impossible to take out a section, and we were at quite a loss to know what to do. It was decided to have a diver go down to investigate, which he did and brought up the top section that was broken out. You understand that the pipe was not broken clear through, but there was just a slash taken out of the top of it by the cutter head of the dredge. It was finally decided to make the repairs with a split sleeve. We could not have purchased one in the open market which would answer the purpose, but there are several large boiler shops in the city and we had one of them make a split sleeve 9 feet 6 inches long which covered and extended beyond the cracks. It was constructed after the manner of the ordinary split sleeve, and required two days to make, working night and day in the boiler shop, as they had to do the work by hand. The ends of that split sleeve were grooved out in order to hold the lead after caulking. It was quite a problem to handle that split sleeve under some 17 feet of water. The sections were lowered from a derrick mounted on the diver's outfit, and the first half of it was held in place by long eye bolts until the two sections were slipped together with a rubber gasket between the flanges. We put a meter on the line to test it, and found that it was leaking about 3 gallons a minute. We left the pressure on for a period of about a week while the government engineers were making certain determinations with reference to the work done by their contractor. At the end of that time they reported a very serious leak at approximately the same point. Our diver had left us, but we called him back again, and it was found that even with the precautions taken to hold the lead in the sleeve, namely, the groove that had been cut around the end of it, the pressure on the line, which was 45 pounds, had forced the lead out. You will understand that it is a rather difficult proposition to work under 17 feet of water with an ordinary hand hammer. We had no data in the office as to the original construction of the line, but we thought it might have been possible that a flanged knuckle joint had been installed. You will understand that you cannot cut out a section of this pipe under water, if you have no flange knuckles, without destroying the ball joints. We secured a bucket dredge to work in the channel some 20 or 30

feet further beyond the break to uncover the pipe in the center of the stream. The diver was then sent down, and with his hose nozzle under about 100 pounds water pressure he washed the pipe clean. A flange knuckle was discovered in this line, and it afforded us considerable relief to find that a certain section of that pipe could be thus taken out, removed to the shore, repaired in the proper manner, and then again lowered down.

The speaker only brings up this subject to show that in the design of a submerged line a flange knuckle joint should be installed at every third or fourth section to facilitate making repairs on the line.

The speaker might cite another example where instead of a Ward joint the pipe is a 20-inch flanged line with Hyde ball joints submerged in the same creek. This was broken by the settling of a barge that had anchored over it notwithstanding that warning signs were placed marking the location of the water pipe. When the tide went down the barge settled on the pipe and broke it. This Hyde ball joint is made up in a manner somewhat similar to the Ward joint except that there is a flange at the joint which has a groove to it which holds the lead in place on the ball of the joint. There are knuckles at every third section, which makes it an easy matter to make repairs. We can take out a broken section of flange pipe, send it to the shop and have both ends turned. We can then put the two pieces together with an ordinary sleeve. This section was then lowered into the creek before it was caulked, and by long bolts extending through pulled together at the flanges and the joints in the sleeve caulked, making a tight job. We have three such lines at Wilmington, one 16-inch, one 12-inch and one 20-inch. Of these two are of the flange and ball joint type; the third one is 12-inch Ward joint pipe.

The speaker does not want what he has said to be considered as any condemnation of the Ward joint. He believes it is good economical joint pipe; but he does advocate and offers what he has said as affecting the design in submerged work, that it is preferable to have flange knuckles at least every third or fourth section.

Mr. M. L. Worrell: In connection with, and in the discussion of, the paper just read, the speaker desires to state that since the paper covering the work at Rome, Georgia, was written, he has completed another crossing through a stream at Meridian, Mississippi, the water works of snake and creosote fame. The method pursued is entirely different from that at Rome and to his mind is worthy of narration here, involving as it does a rather unique construction.

The reservoirs at Meridian, two in number, are situated some two miles from the city and it was in the laying of a 20-inch cast iron pipe for the purpose of bringing more water to the city that the stream referred to was crossed.

The speaker may say, in opening this subject, that the elevation of the bottom of the reservoir is 5.4 feet *only* above the bottom of the settling basin in the city, the elevation of the top of the dam, at high water mark in the reservoirs, being only 16 feet above the top of the settling basin, therefore it was absolutely necessary, if we were to secure the greatest flow, to select a route as near a straight line as possible and to construct the pipe line to an absolute grade, avoiding anything like a summit or high point in the line. With this in view it was deemed advisable to bridge Sowashee Creek, which had to be crossed, on the way to the city. Upon opening bids for the work the prices named were almost prohibitive, besides great danger was apprehended during flood seasons when the stream carries large quantities of driftwood such as uprooted trees, logs from timber cuttings, etc. The speaker was directed by the Meridian water commission to devise a safe plan for crossing under the stream and to proceed with the work.

The route selected was direct, only one turn being necessary, this at an angle of 56 per cent and made by laying the pipe at a radius of 270 feet, thus reducing the friction to a minimum. At the creek there was a downward deflection of approximately 20 feet, the point of beginning being distant, from where grade was resumed 500 feet, scarcely enough for it to be dignified under the title of "Syphon." Sowashee Creek, at the point crossed, carries quite a large amount of sand brought down from the territory above, and my inquiries and observations revealed the fact that the tendency of the creek is to fill and widen and at no time to narrow and scour or deepen. At ordinary winter height this creek, at the point on our route, is 30 feet wide and 9 feet deep. Instead of pursuing the method of laying the river crossing, as at Rome, the speaker conceived the idea of using a truss beam upon which to lay the pipe in saddles, the beam to be 36 feet in length and 3 feet wide, constructed on the order of the bottom of a freight car insofar as the rods used were concerned. The speaker has not the details by him, at this moment, but will be glad to supply a blue print to those members who write to him at Meridian, Mississippi, requesting a copy. The truss beam having been built we took advantage of what seemed to be good weather, and which fortunately proved to be so, and proceeded with the work by placing across the

creek two house moving truss beams, secured from a local contractor, rolled our own beam across on top of them, constructed the pipe, consisting of four joints of the ordinary 20-inch class *A*, cast iron pipe, one blowoff tee, with spigot end 6-inch blowoff valve attached, put everything together by regulation joints of yarn and lead, secured the pipe to the truss beam by U-bolts (bent to a 22-inch radius) and cast iron washers and lowered the entire "bridge" 4.5 feet beneath the surface. Before doing this, however, we cut notches in the banks of the creek the required depth to allow the lowering, thus allowing the beam, with its load, to rest upon solid earth on each side. In order to prevent the pipe from filling with sand we fastened a large barrel head in each end. The lowering of the load, an approximate weight of six tons, was successfully accomplished by the use of two ginpoles and two capstans. After clearing away the rigging and beams we dammed off the waters of the creek at each end of the pipe with sandsacks and easily joined the two ends to the main pipe line approaching and leaving the creek. In order to attain full security we have since driven six creosoted piles in three bents, capping each bent with an oaken timber, well seasoned, and suspending the original construction from these bents with U-bolts. The piles were driven in the bottom of the creek as far as they could be driven, some 12 feet, the upper ends sawed off flush with the top of the pipe, the creek having in the meantime fallen several feet, and the capping attached by means of 100 penny spikes generally used in bridge construction. The method used, you will readily see, allows the water to pass both above and beneath the pipe. It appears to be strong and is absolutely rigid in every direction. We have secured the banks by driving, in crescent shape, two rows of Wakefield piling into the earth as far as they could be driven, some 10 feet or more.

The chief desire, in reporting this method of construction, is the hope that it will prove of practical utility to some member of this association and if, while doing so, the speaker has interested others he will have been more than satisfied.

ELECTROLYSIS FROM STRAY ELECTRIC CURRENTS

By Albert F. Ganz, M.E.

DEFINITION AND THEORY OF ELECTROLYSIS

Electric currents may be conducted in two ways, first, by metallic conduction, and second, by electrolytic conduction. Metallic conduction occurs when an electric current passes through a metal, and is characterized by the fact that no chemical change is produced in the conductor, the only effect being the production of heat. Where electric currents, therefore, pass through metallic conductors, such as copper wires, rails, or pipes, they produce no change in these conductors except to raise their temperature. Under all ordinary conditions stray electric currents found on underground pipes are not sufficiently large to appreciably heat these pipes. Under abnormal conditions pipes may, however, carry stray currents of sufficient magnitude to produce heating at moderately high resistance joints.

Electrolytic conduction occurs when an electric current passes through an electrolyte, and is characterized by the fact that the electric current is transmitted by a corresponding transfer of *ions* in solution, with the production of chemical decomposition at the electrodes where the current enters and leaves the electrolyte. Electrolysis may therefore be defined as chemical decomposition produced by an electric current. Electrolysis is usefully applied in the arts for the refining of metals and for producing chemical compounds. The writer wants to discuss here the destruction of underground structures caused by electrolysis from stray electric currents which reach these structures.

Chemical compounds in solutions of water constitute the ordinary electrolytic conductors. Pure water itself has such a high resistance that it may practically be considered a non-conductor. It is for this reason that an iron pipe full of ordinary city supply water does not have a lower resistance than the same pipe without water. Water is, however, readily made conducting by the addition of small amounts of salts, and conduction through water is therefore always electrolytic.

The following is a brief explanation of the theory of electrolytic

conduction. When a salt is dissolved in water, some of the molecules separate or dissociate into two parts, one part having a positive electrical charge, and the other a negative electrical charge, and these parts are called *ions*. The metal parts or the hydrogen constitute the positive ions, and the acid parts the negative ions. For instance, copper sulphate, $CuSO_4$, when dissolved in water, dissociates into the positive metal ion Cu and the negative acid ion SO_4. An electric current is transmitted through an electrolyte by the transfer of these ions. The electrode by which the current enters the electrolyte is called the *anode*, and the one by which the current leaves is called the *cathode*. The metal or hydrogen (positive) ions travel in the direction of the current and carry positive electrical charges to the cathode, and these metal ions, called cations, are deposited upon or are liberated at the cathode. The acid (negative) ions travel against the current and carry negative electrical charges to the anode, and these acid ions, called anions, will corrode the anode if it is a metal which combines chemically with these anions. The cathode is not corroded. With an electrolyte of copper sulphate dissolved in water, a copper anode corrodes into copper sulphate and dissolves, while metallic copper is deposited upon the cathode. If the electrolyte is common salt dissolved in water, the anions are chlorine, and an iron anode would be corroded, the iron forming ferrous chloride; the cations are sodium, and these would decompose the water present and liberate hydrogen at the cathode. These examples furnish an illustration of the fact that the corrosive action of the current results in supplying the electrolyte with an equivalent of the amount of salt decomposed by the current, so that the electrolyte is continually replenished with salt and its electrolytic conducting power is thereby maintained. This salt will contain metal ions of the anode or hydrogen, and may be different from the original salt which started the action.

Street soils when entirely dry do not conduct electric currents. Under ordinary conditions, however, street soils contain considerable water with salts in solution, generally chlorides, and this makes them electrolytic conductors. When an electric current passes through soil it therefore does so by electrolytic conduction and by corresponding chemical decomposition at the electrodes. Where an electric current leaves an iron pipe for soil it corrodes the iron by this action of electrolysis. It has been claimed in the past that soils may conduct metallically, but this has been disproved and it is now recognized that conduction of electric current through soil is always electrolytic.

The rate at which ions are liberated at the electrodes is propor-

tional to the current strength. With an oxidizing anode, such as iron or lead, the mass of anode corroded by one ampere in one second is equal to the electro-chemical equivalent of the metal of the anode. This is 0.00029 gram for iron (ferrous). From this the mass of iron corroded by one ampere in one year is $0.00029 \times 60 \times 60 \times 24 \times 365 \times 0.002205 = 20$ pounds (approximately). The electrochemical equivalent for lead is 0.0010718 gram, and the mass of lead corroded by one ampere in one year is $0.0010718 \times 60 \times 60 \times 24 \times 365 \times 0.002205 = 74$ pounds (approximately).

The separation of the metal or hydrogen ion from the electrolyte at the cathode absorbs energy from the electric circuit, and generally produces an electromotive force in the opposite direction to the current. The oxidation of the anode supplies energy to the circuit and generally produces an electromotive force in the direction of the current. If the oxidizing anode is of the same metal as is being deposited upon the cathode, and if the electrolyte is the same at the anode and cathode, then there is no resultant electromotive force due to the electrochemical actions, and the only electromotive force consumed is that due to the resistance of the electrolyte in accordance with Ohm's law, exactly as with a metallic conductor. If the metal deposited at the cathode is different from that oxidized at the anode, or if hydrogen is liberated at the cathode, or if the electrolyte at the cathode is not of the same composition or density as at the anode, then there will be a resultant electromotive force, which may be either in the same or in the opposite direction as the current. It has been assumed by some writers in the past that no corrosion from electrolysis can take place if the voltage between two metallic conductors in soil, such as between pipe and rails, is less than 1.5 volts, because this is the dissociation voltage of water. This, however, is entirely wrong, and it has been proven by investigations and is now generally recognized that the amount of corrosion produced by electrolysis is independent of the voltage, except in so far as this determines the amount of current flowing, and that the smallest fraction of a volt can produce corrosion from electrolysis under suitable conditions.

SOURCES OF STRAY ELECTRIC CURRENTS

Stray currents are electric currents which have leaked from grounded electrical distribution systems and flow through ground and through underground structures. Grounded telephone and telegraph lines produce electric currents through ground of such very

small magnitudes that their effects upon underground piping systems can be neglected. Direct-current electric lighting systems in which the distribution is on the Edison 3-wire plan with the neutral conductor grounded, are in American practice provided with such large neutral conductors of copper that practically no stray currents are produced from such systems. This grounding of the neutral in Edison 3-wire systems is to serve as a safeguard and is not for the purpose of using the ground to carry current. Alternating-current lighting systems where grounded generally also produce only small stray currents, and the electrolytic effects from these small stray alternating currents are always negligible.

Electric railways using the running tracks for return conductors often produce comparatively large stray electric currents through

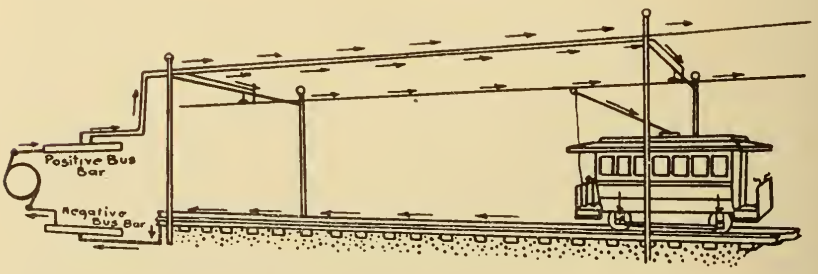


FIG. 1. DIAGRAM OF SINGLE-TROLLEY ELECTRIC RAILWAY SHOWING PATH OF CURRENT FROM GENERATOR THROUGH POSITIVE FEEDERS, TROLLEY WIRE, CAR AND RAILS

ground, and these are the only sources of stray currents which need be considered in practice. Direct current is almost exclusively used for such electric railways and it is the common practice to supply current to the cars from an overhead trolley wire or from a third rail, and to return this current to the power station through the running tracks, supplemented where necessary by return feeders. A single-trolley electric railway is shown diagrammatically in Figure 1, in which the path of the electric current from the positive terminal of the generator through the circuit and back to the negative terminal is shown. The running tracks consist of rail lengths about 40 feet long, and these are mechanically fastened together by fishplates which consist of steel plates bridging across the rail ends and bolted to both rails. Such fishplates while mechanically fastening the rail lengths together do not form good electrically conducting con-

nections between the successive rail lengths. For this reason, copper wires or straps, called rail bonds, are generally used to bridge across the abutting ends of the rail lengths for the purpose of affording a good electrically conducting path between successive rail lengths. The two rails of a single-track road, or the four rails of a double-track road, are also generally connected together at frequent intervals by cross bonds so that the two or the four rails may be available for the return of current. Instead of using copper rail bonds, the rail ends are sometimes welded together, or soft steel plates are welded across each side of the abutting rail ends, thus forming both a strong mechanical and a good electrically conducting connection between the successive rail lengths. A well bonded railway track should have a conductivity not less than 80 per cent of the equivalent conductivity of continuous rails. To give some idea of the relative conductivity of steel rails, it may be stated that a single rail weighing 90 pounds per yard, which is a size commonly used where the traffic is heavy, has about the same conductivity as a copper wire one inch in diameter. Thus the two rails of a single-track line or the four rails of a double-track line laid with 90-pound rails and well bonded afford a good conducting path for electric current.

In the simplest form of single-trolley railway, already shown in Figure 1, the rails are connected to the negative terminal of the generator at the power station, and the only path for current to return to the power station is by way of the running tracks. If the running tracks are laid upon wooden ties above ground with broken stone for road ballast, as is common on steam railroads which run on their own right-of-way, the rails do not come in direct contact with ground, and the return current will be practically confined to the running tracks. If, however, the running tracks are laid below ground so that the top of the rails is on the level of the surface of the street, as is common in cities, then the rails will be exposed for a considerable area to contact with soil. If the tracks are laid on a concrete base a considerable area of the rails will similarly be in contact with the concrete. Since both damp soil and damp concrete are under ordinary conditions conductors of electricity, part of the current returning through the rails will shunt from the rails through the surrounding soil, as is illustrated diagrammatically in Figure 2. It will be seen that with the usual connection of positive terminal of the generator to the trolley wire, and the negative terminal to the rails at the power station, the current will leave the rails for ground at points distant from the power station, and return to the rails in the neighborhood of the power

station, in its path back to the negative terminal of the generator. Since every electric circuit must be completely closed, all current escaping through ground must again leave ground to return to the dynamo so as to complete the electric circuit. Where underground metallic structures, such as gas or water pipes, lie in ground in the path of these stray currents, and where these pipes have electrically conducting joints, such as lead-calked joints or screw-coupling joints, current will flow from ground to such pipes and flow largely on such pipes in a direction towards the power station. In the neighborhood of the power station this current will leave the pipes to return to the negative terminal of the generator, as shown in Figure 2.

If the negative terminal of the generator or negative bus-bar is connected to the rails at other points than at the power station, by means of negative return feeders, then at such connection points the rails will be rendered negative in potential to ground, and currents will tend to flow from underground pipes through ground to return to the rails in the neighborhood of these connections. Stray railway currents on pipes will therefore tend to leave these pipes to return to the rails in all regions where these rails are connected to return feeders.

It must be noted that while ordinary soil is a conductor of electricity, compared with metals its electrical resistance is enormously high; for instance, the resistance between the opposite faces of a foot cube of ordinary soil may measure anywhere from 10 to 1000 ohms, depending upon the amount of moisture and the amount of salts in the soil, while the resistance of a foot cube of iron is equal to about 0.0000004 ohm; if, therefore, we take an average value of 100 ohms for the resistance of a foot cube of soil, it is seen that soil has a resistance which is of the order of 250,000,000 times as great as a body of iron of the same dimensions; that is to say, the conductivity of iron is 250,000,000 times as good as ordinary soil. It would seem from this that current would flow almost entirely on the good conducting rails and none through the high resistance ground. Resistance, however, varies directly as the length and inversely as the cross-section of a conductor, and with the large surface of rails exposed to the ground, the cross-section of the path of the current through ground is enormously great compared with the cross-section of the path of the current through the rails. As a matter of practice it is found that where the rails alone are used for the return of current, frequently a considerable portion of the total current actually leaks from rails through ground.

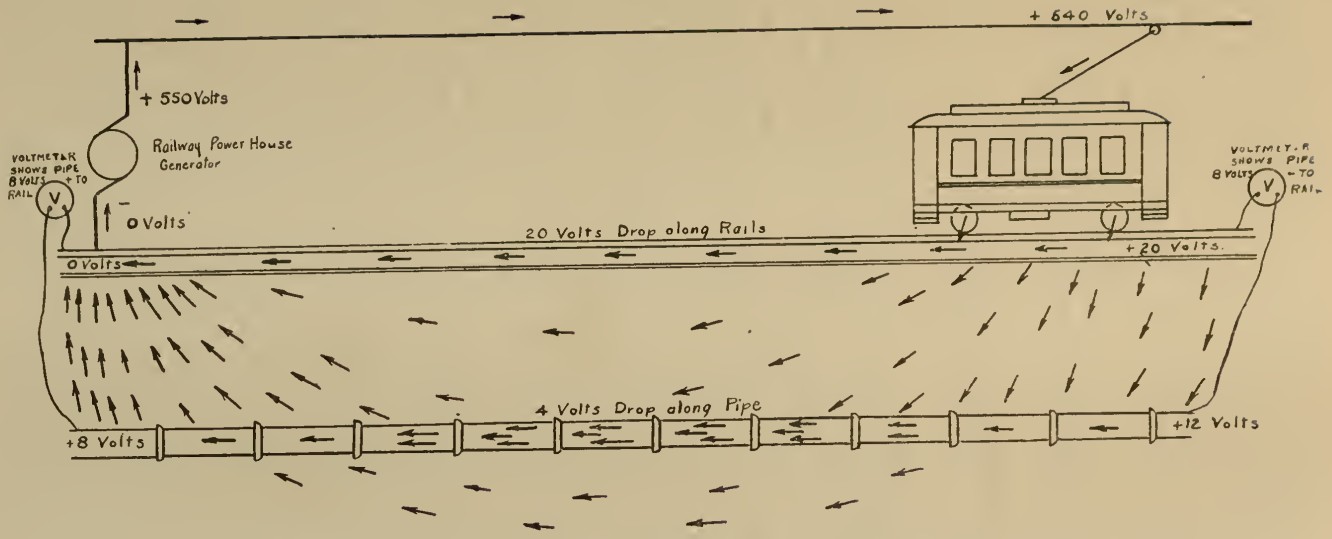


FIG. 2. DIAGRAM SHOWING STRAY RAILWAY CURRENTS WITH ASSUMED DISTRIBUTION OF POTENTIALS CAUSED BY THESE CURRENTS

From the above considerations it will be seen that the leaking of current from the rails of electric railways, producing stray currents through ground and on underground piping, does not constitute a source of loss to the railway company, as for instance would be the case with leakage of gas or water. On the contrary, by allowing the current to return by ground and underground pipes as well as by way of the rails, the total conductivity of the return circuit is increased, and the voltage loss in the return of this current is decreased, so that there is an actual saving of power for the railway company.

GENERAL EFFECTS OF STRAY ELECTRIC CURRENTS ON UNDERGROUND PIPING

The current flowing through the rails from the trolley cars back to the power station produces in these rails a drop in potential; that is to say, points in the rails away from the power station have a positive potential with reference to the rails at the power station. Since potentials are measured relatively it is convenient to consider the negative terminal of the dynamo, which is assumed connected to the rails at the power station, as at zero potential. The distribution of potentials in the rails of a simple electric railway system and in the underground piping is illustrated in Figure 2, in which convenient values have been assumed. It will be noted that the stray current causes the underground pipes to be negative to the rails at points away from the power station, and positive to the rails near the power station. It is also seen that the negative potential of the pipe, plus the drop on the pipe, plus the positive potential of the pipe, equals the drop in the rails. In the case assumed, there is a potential difference of 550 volts maintained at the power station; of this, 10 volts is lost in the trolley wire, 520 volts is used by the motors of the cars, and 20 volts is left to bring the current back to the power station. If the negative bus-bar and the rails at the power station are considered as at zero potential, the rails at the car in the assumed case will have a potential of plus 20 volts. Thus, for practical purposes, the ground with its underground pipes is subjected to a potential difference of 20 volts, and the amount of stray current produced is that due to these 20 volts. If the rails are laid in the usual way, that is, in contact with ground, the 20 volts in the rails will send some shunting current through the ground and through the underground pipe as shown in the diagram. Under the assumed conditions, there is a drop of 8 volts from the rails to the pipe near the car, a drop of 4

volts in the pipe itself, and a drop of 8 volts from the pipe through ground to the rails at the power station. It is therefore seen that it is the potential difference or drop in grounded rails caused by the return current which is the cause of stray currents through ground. Attempts should therefore be made to keep the potential difference or drop in rails as low as practicable in order to keep stray currents through ground down to a minimum.

From the explanation of metallic and electrolytic conduction given in the first part of the paper, it will be understood that where stray currents flow on underground pipes they do no harm except where they leave the pipes to flow to the surrounding soil. At such points corrosion of the iron from electrolysis will take place, and theoretically there will be a loss of 20 pounds of iron per year for every ampere of electric current leaving the iron. Some have assumed that with the low densities at which current generally leaves underground pipes, little or no corrosion is produced. A number of experiments made by the writer have clearly shown, however, that even when current leaves iron for street soil at an extremely low density, corrosion is produced which is at least equal to, and frequently greater than, the theoretical amount. This increase of the actual over the theoretical amount is undoubtedly due to secondary chemical reactions set up by the action of electrolysis.

The underground structures which are most likely to be subjected to destruction from electrolysis caused by stray electric currents, are piping systems and lead cable systems. From what has been said above it will be seen that oxidation or corrosion of such pipes or cable sheaths will occur wherever current leaves the pipe or cable sheath for ground. In the simplest case, illustrated in Figure 2, current flows from rails through ground to the pipes at points distant from the power station, flows along the pipes, and leaves the pipes to return through ground to the rails in the neighborhood of the power station. Where the current flows from the rails to ground, the rails will be corroded, and where the current flows from the pipes to ground, the pipes will be corroded. If the pipe line is a uniform electrical conductor, and the relative arrangements are as shown in Figure 2, then the pipes will be corroded only in the neighborhood of the power station. If, however, the pipe line is not a uniform conductor, as for instance, if there are one or more high resistance joints in this pipe line, then the current on the pipe will shunt around such high resistance joints and produce oxidation or corrosion on one side of the joint. This action gives rise to joint

corrosion which is frequently found. Where there are two or more underground piping systems it also frequently happens that current shunts from one piping system to another through the intervening soil, producing electrolytic corrosion where the current leaves the pipe. Such shunt currents are often caused by accidental high resistance joints in one of the pipe lines, and such shunting may occur anywhere and without reference to the location of the railway power station. Where a direct-current trolley railway system passes through a town which has an independent piping net-work, and where the power station supplying the trolley line is in some other locality, then if stray electric currents are produced from the trolley line where it passes through the town, they will flow on the piping system making this piping system positive to ground and to rails in the direction towards the railway power station, and negative in the direction away from the railway power station. In this case electrolysis of the piping will be produced at the ends of the piping system towards the railway power stations.

Where current leaves a wrought-iron or steel pipe for ground, the oxide of iron resulting from electrolysis is diffused through the soil and streaks of iron oxide can generally be found in the surrounding soil. Electrolysis of wrought-iron or steel pipes usually results in pits which eventually go entirely through the wall of the pipe. It has frequently been found in practice in the case of gas pipes that where a service pipe lies in clay or other tightly packed soil, it may be pitted through in many places without giving any external sign of leakage because the soil surrounding the pipe maintains it gas tight. When cast iron is corroded by electrolysis, the oxides of iron mixed with graphite usually remain in place leaving the outside appearance of the pipe unchanged. This material resulting from electrolysis of cast iron usually has the consistency of hard graphite, and can be cut with an ordinary knife. There have been many cases in which a cast-iron main was carrying gas or water without any apparent leak, where a single blow with a hammer drove a hole right through the pipe. Here the electrolytic action had corroded the iron entirely through the pipe, and the oxide of iron had remained in place, and, together with the surrounding soil, had prevented the pipe from leaking. Whether or not the mixture of iron oxide and graphite resulting from electrolysis remains in place so as to maintain a pipe gas or water tight, depends upon the surrounding soil conditions. It is therefore seen that an underground piping system may be suffering severely from electrolysis without having given any outward sign

of the damage. A physical examination with a test hammer is required in the case of cast-iron piping to establish definitely whether or not it has been damaged by electrolysis.

For a given current leaving an iron pipe, there is practically no difference in the amount of iron destroyed between cast iron, wrought iron and steel. The electrical resistivity of cast iron is, however, about ten times as great as that of wrought iron or steel, and the usual lead joints in cast-iron pipes also have a resistance which is many times greater than the screw-coupling joints usual with wrought-iron and steel pipes. For these reasons a given voltage drop through ground will cause a much smaller current to flow on a cast-iron pipe than on a wrought-iron or steel pipe, thus practically making cast-iron pipes much less subject to electrolysis than wrought-iron or steel pipes. The most frequent damage from electrolysis is found in the case of service pipes where these cross under trolley rails or other underground conductors to which they are positive. Examples of destruction of pipes by electrolysis which are often found in practice will be taken up in a later chapter under the heading of "Damage and Danger Produced by Stray Electric Currents on Underground Piping."

ELECTROLYSIS SURVEYS

The diagram illustrated in Figure 2 shows that voltage drop in the rails produces stray current through ground and through underground pipes, and produces potential differences between pipe and rails, making the pipe appear positive in potential where current leaves the pipe, and negative in potential where current flows to the pipe. The first step in an electrolysis survey of a town is, therefore, to measure potential differences between pipes and rails, at a number of points throughout every street on which there are electric railways. Where the main itself is not exposed, connections to the pipes for these voltmeter measurements may be obtained by means of service pipe or drip connections. Such connections are generally satisfactory because the voltmeter itself has a high resistance and takes only a very small current. Readings are taken at each point every ten seconds for ten or twenty minutes depending upon the car schedules, and the maximum, minimum and average results of the readings recorded. A convenient instrument for these potential readings, which can also be used for the drop measurements described below, is a Weston Model 1 combination millivoltmeter and voltmeter, with its zero in the center of the scale, and having ranges of 5, 50 and 500 millivolts

and of 5 and 50 volts. These intruments are made with very high resistance; so as to be particularly applicable to electrolysis testing.

After such potential measurements have been made throughout the principal streets of a town, they are then conveniently plotted on a skeleton map of the town, in which the trolley lines are shown. The potentials of the pipes referred to the rails are laid off normal to the lines representing the railway tracks to some convenient scale, usually 1 inch = 10 volts. The ends of these potential lines are then connected, and the included areas are colored red where the pipes

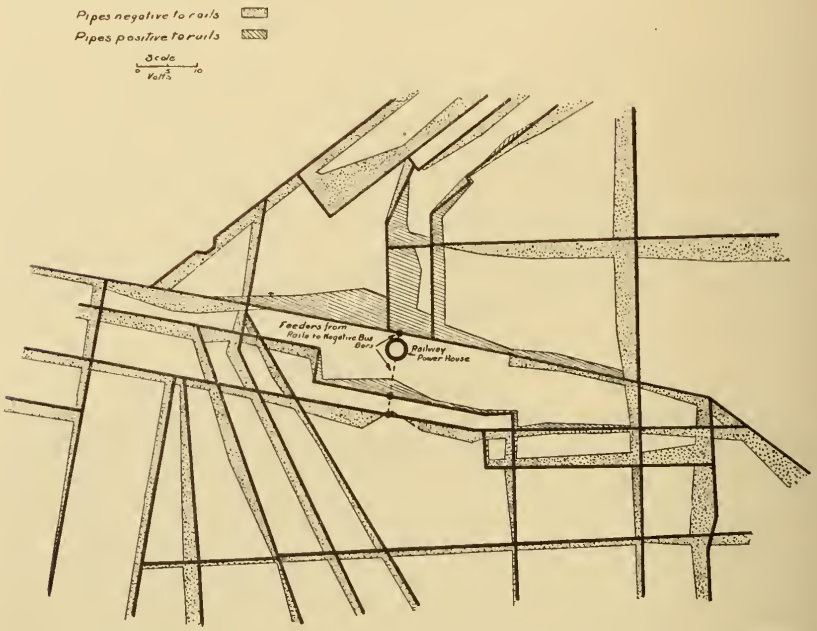


Fig. 3. Typical Potential Survey Plotted on Skeleton Map of City Showing Electric Railway Tracks and Potentials of Underground Pipes Referred to Trolley Rails

are positive in potential to the rails, and blue where the pipes are negative in potential. In Figure 3 is shown a typical potential survey map, in which the negative areas are shown by dots, and the positive areas by section lines, instead of by blue and red areas. It will be noted that in the neighborhood of the railway power station the pipes are highly positive to the rails, and at points distant from this station they are negative to the rails. The existence of potential differences between pipes and rails is, however, no conclusive evidence

of stray currents on the pipes; they indicate at what points current is probably flowing from rails to pipes and from pipes to rails.

The next step in the survey is to measure drop between drip or service connections, which will indicate the probable existence and direction of current flow on the pipes. Such drop measurements cannot, however, be used for calculating the amount of current on the pipes. To determine the actual current flowing it is necessary to measure the drop between two points on a continuous length of pipe by means of a millivoltmeter. This drop expressed in volts divided by the assumed or measured resistance in ohms of the included length of pipe gives the current expressed in amperes. A convenient table giving the current in amperes for 1 millivolt drop in 1 foot of standard wrought-iron and cast-iron pipes is appended to this paper. To find the current flowing on a pipe corresponding to a given drop in milli-

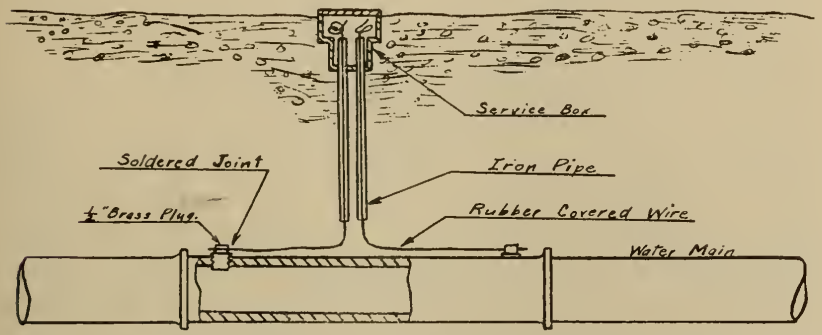


FIG. 4. PERMANENT ELECTRICAL TEST WIRES ATTACHED TO MAIN AND BROUGHT TO SURFACE OF STREET THROUGH SERVICE BOX

volts for a measured length, multiply the amperes given in the table for 1 millivolt drop for 1 foot by the number of millivolts drop measured, and divide by the included length of pipe in feet. To measure this drop, it is necessary to expose the pipe and to make good electrical contact between the millivoltmeter leads and the pipe. A satisfactory method is to use a pointed piece of steel, about the size of an ordinary lead pencil, fastened in a wooden handle, with a flexible connecting wire soldered to it inside of the handle. The pointed steel is then pressed against a bright spot or into a filed notch on the pipe. A still better contact is obtained by soldering the connecting wire directly to the pipe or to a brass plug screwed into the pipe, which is particularly advantageous when readings are to be taken over a considerable time. When such contact wires have been

soldered to a continuous length of pipe, it is usual to use rubber covered wires and bring them to the surface of the street, leaving the ends in drip or service boxes which then form permanent test stations for electrical measurements. This is exceedingly convenient because it is then possible to make current measurements on the pipe without

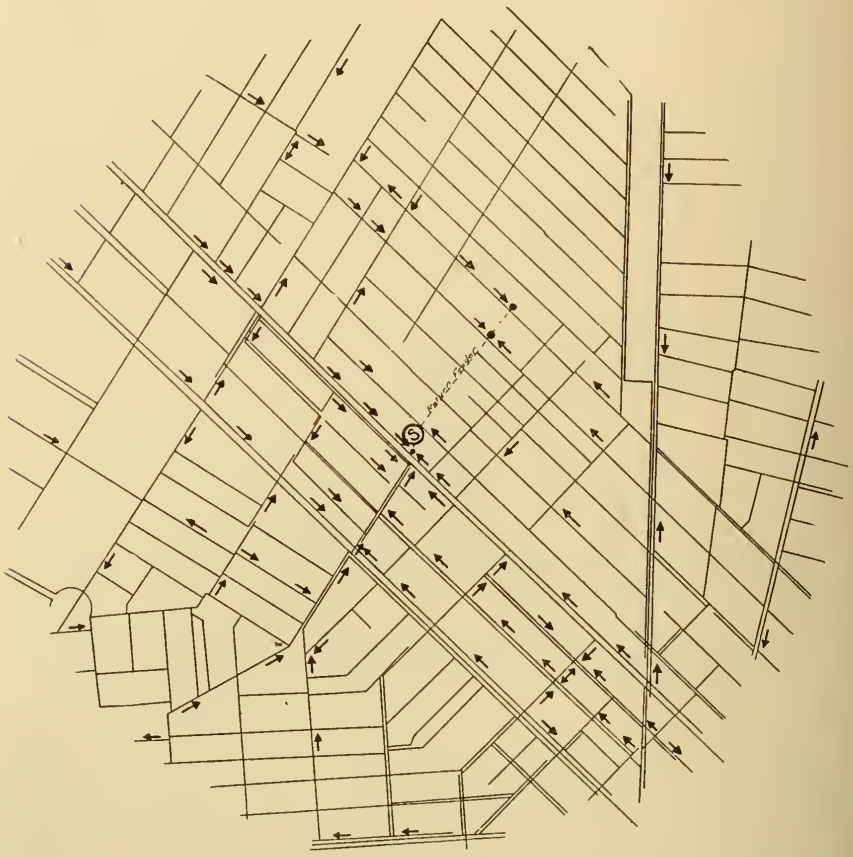


FIG. 5. TYPICAL CURRENT SURVEY PLOTTED ON SKELETON MAP OF SECTION OF CITY SHOWING UNDERGROUND MAINS AND STRAY CURRENTS FLOWING ON MAINS

again making an excavation. Such permanent contact wires for electrical tests are illustrated in Figure 4.

When drop measurements between services and current measurements on pipes have been generally made on a piping system, the results are conveniently plotted on a skeleton map of the city in which

the pipe lines are shown and the current flowing on these pipes are indicated by arrows. A typical current survey map of a portion of a city is shown in Figure 5. It is seen that here the currents on the pipes flow in a general direction towards the railway substation.

Since current destroys the pipe only where it leaves for soil, it is important to know where the current leaves the pipe. Current measurements on pipes are therefore frequently made at two or more stations simultaneously in order to determine the change of current on the pipe between the stations. In Figure 6 simultaneous current

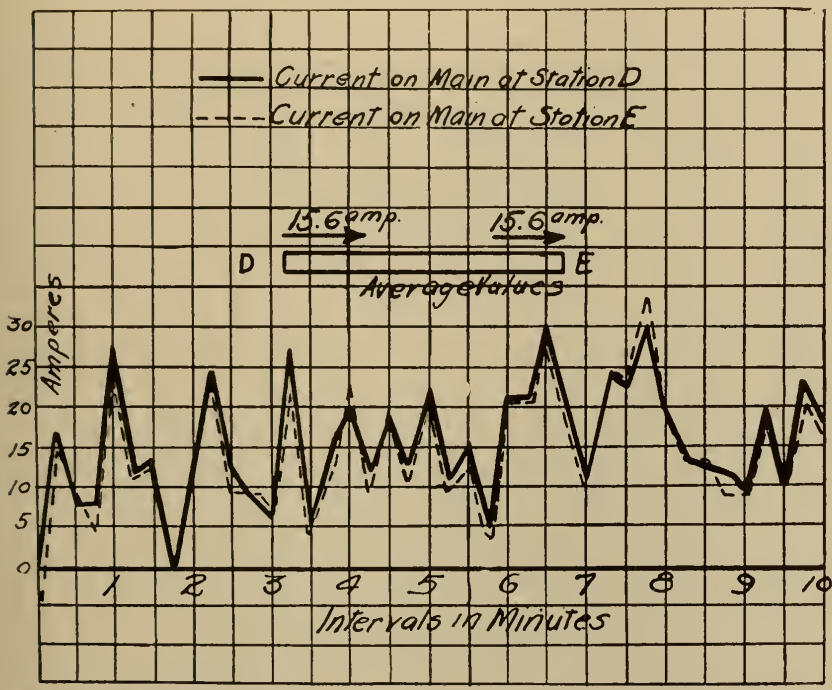


FIG. 6. SIMULTANEOUS CURRENT MEASUREMENTS AT TWO STATIONS ON MAIN WHERE THERE IS NO CHANGE IN CURRENT BETWEEN STATIONS

measurements made at two stations on a pipe are shown plotted where there is no change of current between the stations. In Figure 7 simultaneous current measurements at two stations on a pipe where there is a considerable loss of current between the stations are likewise shown.

In order to determine the characteristic variations of a potential difference between pipe and rails, or of current flow on a pipe, twenty-

four-hour records of such potential difference or of current flow may be obtained by means of a special Bristol smoked-chart recording instrument. This recorder has for its measuring system a sensitive Weston millivoltmeter, and may be provided with a number of ranges. It is convenient to have the instrument provided with its zero in the center of the scale, and with ranges of 5, 50 and 500 millivolts, and of 5 and 50 volts. Shunts of any desired ampere range can also be used in connection with the recording millivoltmeter, and the instrument used as a recording ammeter of a corresponding range. Convenient shunts for this are ordinary switchboard shunts adjusted for 50 milli-

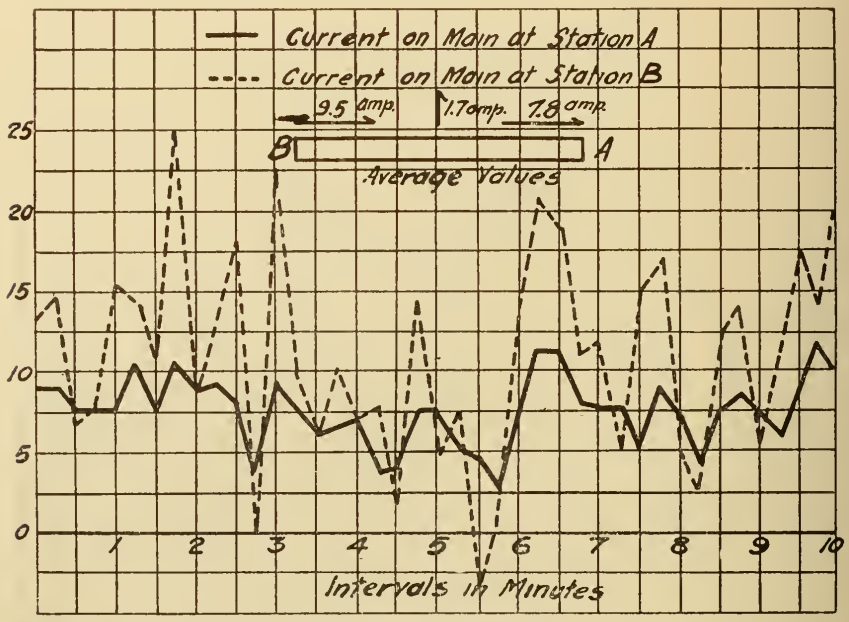


Fig. 7. Simultaneous Current Measurements at Two Stations on Main Where There is Change in Current Between Stations

volts drop, with rated capacities of 5, 50 and 500 amperes. Such potential and current records are conveniently plotted from these charts in rectangular coördinates. Sample twenty-four-hour records of current on a pipe plotted in rectangular coördinates for one week are shown in Figure 8.

It will be seen from Figure 8 that the current records for week days are practically alike, and show morning and early evening peaks. The record for Sunday is however, very different and shows a very

large peak throughout the whole afternoon. This is accounted for by the fact that the neighboring trolleys were carrying large crowds of excursionists on Sunday outings. By means of such twenty-four-hour records, it is often possible to positively identify the source of current flowing on a pipe as railway current from its similarity with the railway load curves. Twenty-four-hour records of current flowing on pipes may also be obtained at two or more stations simultaneously, and the change of current between the stations for the twenty-four hours determined.

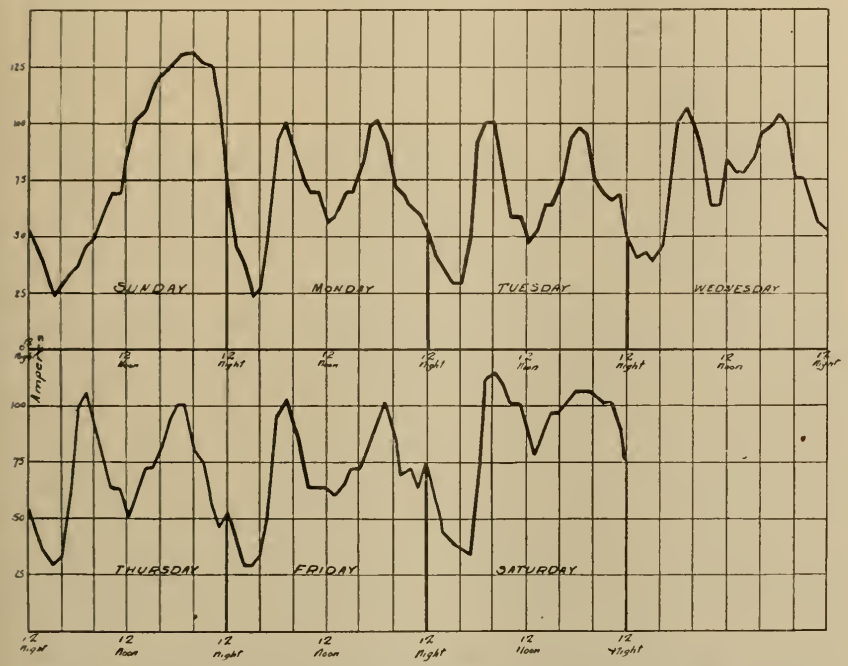


FIG. 8. STRAY CURRENTS ON WATER MAIN AVERAGED FROM BRISTOL TWENTY-FOUR-HOUR RECORDS AND PLOTTED FOR ONE WEEK

It is possible to trace the path of current flow through ground by measuring potential differences between points in the ground. Where small potential differences are measured between two points in ground and iron rods are used as electrodes, entirely incorrect results may be obtained because of possible differences in polarization voltages at the surfaces of the electrodes. To overcome this difficulty, a "non-polarizable electrode" was devised by Professor Haber. This consists of a glass tube with a porous cup cemented to one end and containing

a saturated solution of zinc sulphate, and of a zinc rod dipping into the solution. A wire is brought out from this zinc rod through a cork in the top of the tube. To make contact to ground with this electrode the porous cup is pressed against the part of the ground at which the potential is to be measured, thus establishing contact between the ground and the zinc sulphate solution. This establishment of electrolytic contact between ground and the zinc sulphate solution eliminates polarization voltages. The polarization voltage between the zinc rod and the zinc sulphate solution, which is a definite known voltage, must be allowed for when using this electrode. It is also essential that when this electrode is used, the potential measurements be made by means of zero methods, and not with indicating voltmeters, because of the very high contact resistance produced with this electrode.

It is often also desirable to measure directly the flow of current through ground, as between a pipe and rails, or between two pipes. This can be done by means of an earth ammeter, which was also devised by Professor Haber. This consists of a wooden frame with two copper plates insulated from each other by a plate of mica or glass. Insulated copper wires are brought out from the two copper plates, and these wires are connected to an ammeter. To use the frame, the two copper plates are first coated with a paste made of copper sulphate and a 20 per cent sulphuric acid solution. A wetted piece of parchment paper is then laid over the paste, and the remainder of the frame filled with soil from the excavation where the current flow through ground is to be measured. The frame is then buried in ground normal to the direction of the current flow to be measured, and the ammeter will indicate the current flow which is intercepted by the buried frame. The object of the copper sulphate paste on each plate is to equalize polarization potentials at the surfaces of the copper plates. This earth ammeter is also well suited for measuring current flow between pipe and ground. For this purpose the frame is buried in the ground one or two inches from and parallel to the pipe. Measurement of current flow from a pipe thus made can be used to form an estimate of the probable amount of electrolytic damage to the pipe, and in cases where corrosion has taken place, this kind of test will often serve as evidence that the corrosion has been caused at least in part by stray currents leaving the pipe. By using a recording instrument in connection with the earth ammeter, the characteristic variations of the current leaving a pipe can also be determined and in this way the identity of the current can often be established.

From a study of the results of the survey it can be determined where current is leaving the piping. At a number of such points excavations should then be made and the exposed pipe examined with a test hammer for electrolytic corrosion. Where such corrosion and pitting is found at points where current is found leaving the pipe, it may be taken as evidence that the destruction was caused by electrolysis, because it has been conclusively proven that current cannot leave iron for surrounding soil without producing corresponding destruction of the iron.

Regarding the use and value of an electrolysis survey, it must be remembered that the object of the survey is to indicate the existence or non-existence of stray electric currents upon a piping system, and to determine where such currents flow on to the pipes and from the pipes. I have had occasion to examine a large number of electrolysis surveys and have found that many of these consist exclusively of voltmeter readings. Such readings by themselves do not afford a measure of electrolytic danger; they merely indicate where the greatest danger is likely to exist. Measurements of current flow on pipes are essential in an electrolysis survey because all current which flows on a pipe must leave it, and the amount of damage produced is proportional to the total current which leaves the pipe. I have seen some reports on the other hand, where it is stated that the current on a given pipe is zero, but where the instruments and methods employed were not sufficiently sensitive to detect current as large as two or three amperes, and where, therefore, the conclusion of zero current is not warranted. From a complete and properly analyzed electrolysis survey, a great deal of good can generally be accomplished. It will not always be possible to remove all stray currents from the pipes, but measures will be indicated by which the conditions can be greatly improved, and points of greatest danger will be located. If then trouble does occur at a later time at these points, the electrolysis survey may be most valuable in affording proof of the destruction of the property from railway currents and may be the means of compelling the railroad company not only to pay for the damage but also to make improvements in its return system so as to avoid the recurrence of such damage. I know of a number of electric railroad companies who are regularly paying for damage caused by electrolysis to piping systems. The knowledge that a pipe owning company is making electrolysis tests and is keeping watch on the situation, also has a strong moral effect on the electric railroads.

DAMAGE AND DANGER PRODUCED BY STRAY ELECTRIC CURRENTS ON UNDERGROUND PIPING

It has already been pointed out that damage from electrolysis to underground piping usually results in the neighborhood of the power station from current leaving the pipe to flow to the rails and to other return conductors, and that service pipes in the same locality are most frequently damaged where they cross under and are positive to trolley rails. The destruction of underground piping by electrolysis is, however, by no means confined to positive districts in the neighbor-

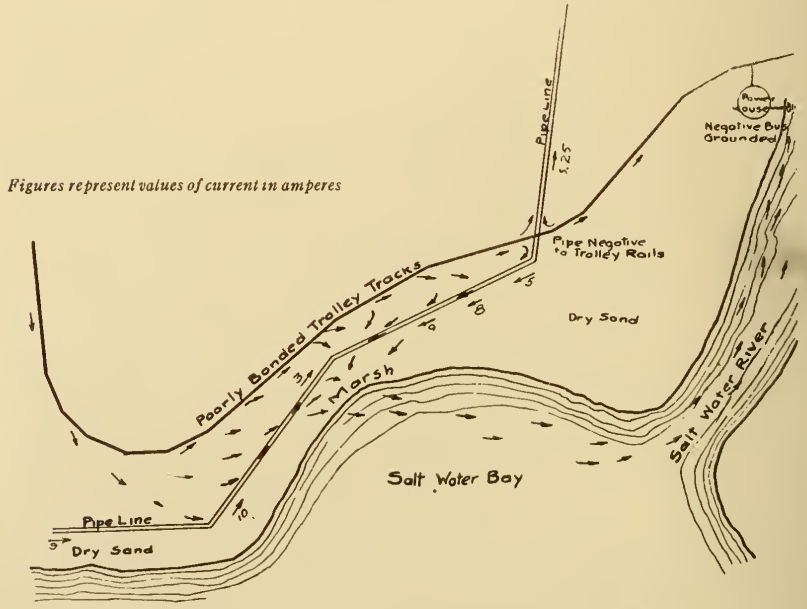


FIG. 9. DIAGRAM SHOWING STRAY CURRENT LEAVING WATER MAIN IN NEGATIVE DISTRICT

hood of the railway power station, but will occur at any point in the pipe where current leaves the pipe to flow to the surrounding soil. In Figure 9 is shown a water pipe and trolley line near a salt-water bay, about eight miles distant from the railway power station supplying this trolley road. The trolley rails at this point are about 25 volts positive to the water pipe, that is the water piping is in a highly negative district. The railway power station is located on the shore of a salt-water bay, and its negative bus-bar is grounded through low-resistance ground connections, so that large currents leak from the trolley

rails at points shown in Figure 9, and flow through the ground and the salt water of the bay to return to the negative bus bar at the railway power station. These stray currents in their path encounter the water main and flow part of the way on the water main. The values of current indicated on the main are average values obtained from twenty-four-hour records. It is seen that in one section large currents leave this water main to flow to the surrounding soil and from there to the salt water. An examination of the main at this point also indicated that it had been badly corroded by electrolysis. This therefore affords an excellent example of destruction by electrolysis of a water main in a highly negative district.

In Figure 10 is also shown a water main and service pipe crossing under trolley rails and under telephone ducts. At this point the pipe is also negative to the trolley rails, but positive to the lead sheaths of the telephone cables, the potential condition with reference to the

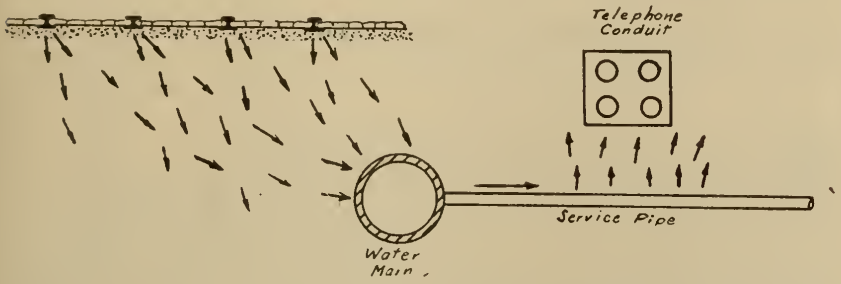


Fig. 10. Example of Service Pipe Negative to Trolley Rails and Destroyed by Electrolysis Due to Currents Flowing from Rails to Pipe and from Pipe to Telephone Cable Sheaths

cables being caused by the fact that the telephone cable sheaths are bonded to the railway return conductor at the power station. As shown in the diagram, current flows from the rails to the water pipe, and leaves the water service pipe where it crosses under the telephone ducts to flow to the cable sheaths, resulting in the destruction of the service pipe. An examination showed pits extending entirely through the service pipe directly under the telephone ducts and facing the ducts. This therefore affords another illustration of destruction of a service pipe in a negative district.

Besides danger from electrolytic destruction of the pipes, stray currents where they flow on underground piping systems frequently enter buildings through service connections and produce a serious fire hazard. For example, current may flow into a building through

a water service pipe, then flow from the house water piping to the house gas piping, and then out from the building through the gas service pipe. An example of this kind frequently met in practice is illustrated in Figure 11. Such contacts between service pipes or between a service pipe and the lead sheathing of a telephone or a power cable frequently occur through metal ceilings, or where the pipes rest against each other. Since dangerous heating may be produced where the current flows through such contacts or where vibration may momentarily separate the contacts and produce an arc, near-by inflammable material is in danger of being set on fire. The author has in fact found many cases where currents up to 30 amperes were flowing into and out of buildings through service pipes or lead cable sheaths. Evidences of arcing having occurred between such contacts in buildings have also been found. There is no doubt that many

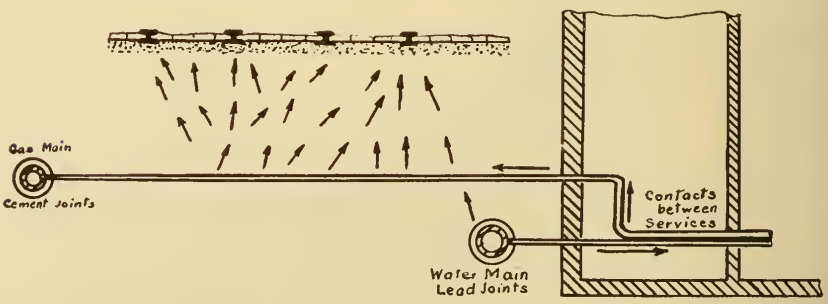


FIG. 11. DIAGRAM SHOWING STRAY CURRENTS ENTERING AND LEAVING BUILDING THROUGH SERVICE PIPES AND CAUSING FIRE HAZARD AND ALSO DESTROYING GAS SERVICE PIPE BY ELECTROLYSIS

fires have started in this way, but it is always difficult to prove the cause of a fire because of the destruction resulting from the fire.

CORROSION NOT CAUSED BY ELECTROLYSIS

While electrolysis is undoubtedly responsible for much destruction of underground piping and other underground metallic structures, the author has frequently been asked to examine cases where the destruction had clearly not been produced by electrolysis from stray currents, but by altogether different causes. It must be remembered that corrosion of a metal from electrolysis can only occur where current leaves the metal to pass to an electrolyte such as damp soil. Service pipes have sometimes been found destroyed inside of cellar

walls where they were not in contact with an electrolyte; the corrosion here is purely of a chemical nature, and not in any way chargeable to stray current electrolysis. Brass or copper pipes and fittings and condenser tubes in contact with salt water also corrode quite generally, but this is caused by electrochemical action of the salt or contaminated water upon the metal, and not by electrolysis from stray currents. In some cases steel in reinforced concrete construction has also been found to be corroded, and the author has had occasion to investigate one important case where the steel reinforcement of a reinforced concrete building had been badly corroded, and where electrolysis from stray railway currents was claimed to be the cause of the corrosion. The construction however was such that there was no possibility of stray railway currents having passed from the steel to the surrounding concrete, which would be an absolutely essential requirement for the destruction by electrolysis, and the case was a clear one of corrosion from ordinary chemical causes. It is therefore wise where doubt exists to make a careful examination and determine positively whether or not a given case of corrosion was caused by stray current electrolysis.

REMEDIAL MEASURES

There is only one complete remedy for electrolysis, and that is the use of a completely insulated return circuit. Such railways may be provided with double overhead trolley wires, as used for example in Washington, D. C., Cincinnati and Havana; or with an insulated outgoing and return conductor in underground conduits, as used for example on the surface lines on Manhattan Island; or with separate insulated third and fourth rails for the outgoing and return current, as is used on the Metropolitan District Railway in London. With these systems the running tracks are not used as a part of the electric circuit, and as both positive and negative sides of the circuit are insulated no stray currents are produced.

Where a road operates on a private right-of-way, the rails can often be practically insulated from ground and the escape of current from the tracks prevented. For surface roads this can be practically accomplished by placing the rails on wooden ties above ground and using broken stone for ballast and keeping the rails out of contact with ground. In the case of railway lines operating on elevated structures the rails can be fastened to wooden ties and kept out of contact with the structure. These rails, supplemented where necessary with negative feeder cables, also insulated from the structure,

can then be used for the return conductor. In this way the return circuit is quite thoroughly insulated from the elevated structure and from ground, and stray currents are entirely prevented.

A number of remedial measures intended to reduce stray currents from electric railways using the grounded rails for a return conductor have been tried. These methods may be divided into two classes, the first class aiming to remove the current harmlessly from pipes by metallic connections or bonds between the pipes and the railway return circuit, and the second aiming to minimize stray currents through ground.

Since stray currents cause damage only where they leave pipes to flow to the surrounding soil, attempts are frequently made to prevent destruction from electrolysis by connecting or bonding the pipes or other structures by means of metallic conductors to the rails or to the negative return circuit, so as to remove the electric current by metallic conduction and thus prevent corrosion from electrolysis. This method can protect lead cable sheaths because they form continuous electrical conductors, but it is not generally applicable to underground piping systems, because the latter do not form continuous electrical conductors, but are more or less discontinuous networks. While lead-calked joints usually have a relatively low resistance, it frequently happens that they develop such high resistances as to make them practically insulating joints, due undoubtedly to the formation of oxide coatings. Cement joints and cement pipes have such a high resistance compared with iron pipes that they are practically insulating. Bonding of pipes to the rails or to the negative return circuit can only afford local protection to the extent that the piping connected forms a continuous metallic conductor, and this latter is an unknown and indeterminate quantity in a piping network. In the practical working out of a bonding or drainage system two opposing tendencies develop; first, there is a reduction in the difference of potential between pipes and rails in the positive areas, and consequent reduction of damage in those areas; and second, there is an increase of current flow on the pipes throughout the entire system, thus increasing the danger of trouble at high resistance joints, or other places where two piping systems or separate portions of the same system are electrically discontinuous. As a rule, in the early stages of this system and especially in small networks when there are comparatively few bond connections, and the resistances of the paths over the pipes are therefore relatively high, the effect is apt to be beneficial, reducing the danger in positive areas more than it increases the danger

elsewhere. As the system grows and the load increases, more and heavier bonds become necessary. The current on the pipes may finally become so great that the trouble from current shunting around joints or between separate systems will increase more rapidly than the danger in the positive areas is reduced, and any further increase in the bonding becomes an actual source of danger to the system. Since bonding transfers the trouble from the region where it was most evident to a new locality where it may require several years to manifest itself, the false impression is created that the trouble has been removed. It is due largely to this obscure manner in which trouble develops that has caused this method to become quite widely used. A number of cases have in fact been reported where a main bonded to the negative return circuit at the power station was completely destroyed by electrolysis a block or two away, because of a high resistance joint in the main forcing current to shunt around the joint

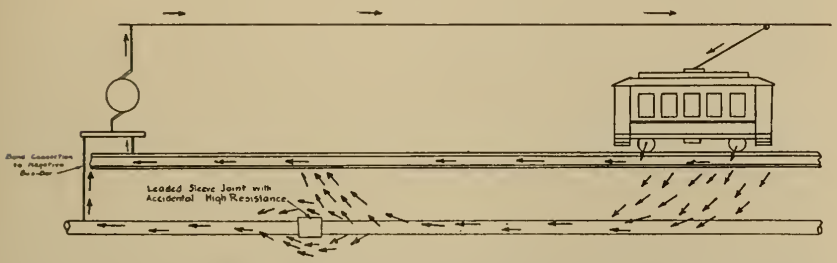


FIG. 12. DIAGRAM SHOWING INCREASED DANGER FROM ELECTROLYSIS FROM BONDING PIPE TO RAILS CAUSED BY ACCIDENTAL HIGH RESISTANCE JOINT IN PIPE

and leave the main a short distance away from the power station. In one of these cases one entire block of main had to be replaced. This case is illustrated in Figure 12. In another case, the water main on one side of the street was bonded to the negative return circuit at the power station, and a main on the opposite side of the same street, although connected through cross-piping to the bonded main, was completely destroyed because high resistance joints had developed in the connecting pipes. In addition, bonding pipes as a means of protection always renders the bonded structures a part of the negative return circuit, and therefore a source of danger to other underground structures which are not bonded. It has in fact been frequently found that where gas or water service pipes cross bonded cable sheaths, currents are caused to flow from the service pipes to the

cable sheaths, and produce gradual destruction of the service pipes. A case of this kind was illustrated in Figure 11. In the case of one city nineteen service pipes were destroyed in the course of one year directly where these pipes cross telephone ducts containing cables whose sheaths were bonded to the railway return circuit. One engineer who has studied this problem very carefully and entirely impartially has very aptly likened bonding to the drug habit, producing temporary relief at the expense of permanent and perhaps irreparable injury to the victim, which injury is, however, too rarely attributed to the true cause.

Among the methods which have been used to minimize the escape of currents on systems using the grounded rails for the return conductor are increasing the resistance between rails and ground, increasing the resistance between pipes and ground, increasing the resistance along the line of the pipe by means of high resistance joints, and decreasing the drop in potential in the grounded rails.

The resistance between rails and ground can often be increased by using broken stone ballast, whereby the rails are kept out of contact with ground and water is allowed to trickle away from the rails thereby maintaining high resistance between the rails and ground. Where an electric railway owns its own right-of-way, it is frequently feasible as already stated to practically insulate the rails from ground.

Attempts have been made to insulate pipes from ground by paints, dips and insulating coverings. Experience as well as a large number of tests on such paints and dips have however shown that no dip or paint will protect a pipe against electrolysis in wet soil. The first difficulty is the mechanical one of applying the paint so as to form an absolutely perfect coating, and then to prevent mechanical damage to the coating. Where imperfections exist or develop aggravated trouble always ensues. Experience further shows that even where paints or dips are apparently intact and perfect, electrolytic action is not prevented, and in fact very serious electrolytic pittings have been found under apparently good coatings. It has been found that in most cases the coatings applied have either been completely destroyed by the effects of the wet soil and the electric currents, or defects in the coating have developed causing concentrated corrosion at such defective spots. The destruction of paints in wet soil where subjected to an electric current is due to traces of moisture finding their way through the coating, giving rise to the flow of a feeble current and resulting in a very slight amount of electrolysis. The gases and other products of electrolysis then form blisters and finally rupture the coating.

Pipes in positive districts coated with imperfect insulating coatings are in greater danger from electrolysis than bare pipes. Coating pipes in negative districts with insulating covering does some good in reducing the amount of stray current which reaches the pipes. Where it is attempted to apply a heated material, like pitch or asphaltum, to a cold pipe, it is impossible to completely cover the pipe. The only kind of insulating covering which appears to afford certain protection is a layer of at least one or two inches of a material like coal tar pitch or asphaltum, of such a grade that it is not brittle and so will not crack, but yet is hard enough to remain in place. The best way to apply such a layer is to surround the pipe with a wooden box, support the pipe upon creosoted blocks of wood or upon blocks of glass, and then fill the space between the box and pipe with the molten material. As a further protection an insulated coupling should be introduced at each end of the section covered so that even if the covering should become defective at any point or points no current can reach the pipe to corrode it by electrolysis. A pipe treated in this way with the work done so as to be mechanically perfect would undoubtedly be protected from electrolysis. However, the cost of carrying out such an installation is absolutely prohibitive, except in a few cases, such as in the case of service pipes in very bad localities or in the case of some very important individual pipe lines of small size. It is not sufficient to apply the covering only in the positive district, nor on the other hand, is it always necessary to cover the entire length of line. The portions which must be insulated can only be determined by properly conducted electrical tests. Experience has also shown that embedding a pipe in cement or concrete, even if this is several inches in thickness, does not protect the pipe from electrolysis, and in some cases it has been found that the pipe in concrete is destroyed at least as rapidly as when it is buried in ground.

Current flow on pipe lines can also be practically prevented by using insulating joints for every joint. Cement joints as ordinarily made do not generally produce metallic connection between the two pipes and may practically be classed with insulating joints. The cause of the high resistance of cement joints is probably due to the fact that although every attempt is made to push the spigot end home into the bell when laying cast-iron pipe, as a matter of fact in most cases the two pipes are not in metallic contact. Even where there is metallic contact this is probably over a comparatively small area, if not at a point. As the end of the spigot is always heavily coated with scale, such metallic contact generally forms a poor electrical connection of

comparatively high resistance. It is a simple matter to positively prevent metallic contact by inserting a ring of some cheap insulating material such as fiber or cardboard between the end of the spigo and the interior of the bell, and this has been done in some cases. The resistance of cement joints is then the electrical resistance of the cement intervening between the spigot and bell, and while cement is not an insulator but on the contrary is probably as good a conductor as ordinary ground, yet compared with iron the resistance is so high that the cement joints practically interrupt the electrical continuity of the pipe line. A pipe line laid with all cement joints or with all insulating joints is therefore a discontinuous electrical conductor and is not capable of carrying stray electric currents. Such a pipe line therefore cannot pick up current in an extensive negative area to discharge it in a restricted positive area, which is generally the cause of the most serious electrolytic danger. For this reason a piping system with all cement or insulating joints is on the whole much less likely to be affected by electrolysis than a piping system with all lead or screw-coupling joints. Experience has shown however that a cement-jointed piping system is by no means immune from electrolysis, and there is abundant experience which shows that cement-jointed mains and especially service pipes from such mains can suffer severely from electrolysis. In these cases the stray currents reach the mains and service pipes from other pipes or by other paths. An example of a gas service pipe from a cement-jointed main destroyed by electrolysis from stray currents which reached the gas service pipe from the water piping is illustrated in Figure 11.

A convenient form of insulating joint for small wrought-iron or steel pipes is the Macallen joint which is illustrated in Figure 13. This is very largely used for insulating water and gas service pipes. A convenient form of insulating joint for large pipes is illustrated in Figure 14, where a flanged joint is shown with a fiber disc between the surfaces of the flanges, and with the bolts insulated with fiber tubing and the bolt heads and nuts insulated with fiber washers. This form of flanged insulating joint has been very largely used for water and gas mains. The Dresser insulating joints are also very satisfactory. Insulating joints can often be used to great advantage in special cases, as for example in the case illustrated in Figure 11, where an insulating joint in the gas service inside of the building would protect the gas service pipe, by preventing the current from flowing out of the building on this pipe. Insulating joints on mains must, however, be used with very great caution, as they can under

unfavorable conditions do more harm than good. It is sometimes possible to use comparatively few insulating joints to break up the electrical continuity of a pipe line, and protect the pipe line from electrolysis, but such joints must be installed only after careful tests have shown that the current is not likely to shunt through ground around them. This depends largely upon the potential gradient through ground and upon the electrical resistance of the ground.

While relief from serious electrolysis can at times be obtained by such special measures as insulating pipe coverings or insulating joints, it must be understood that all remedial measures should have

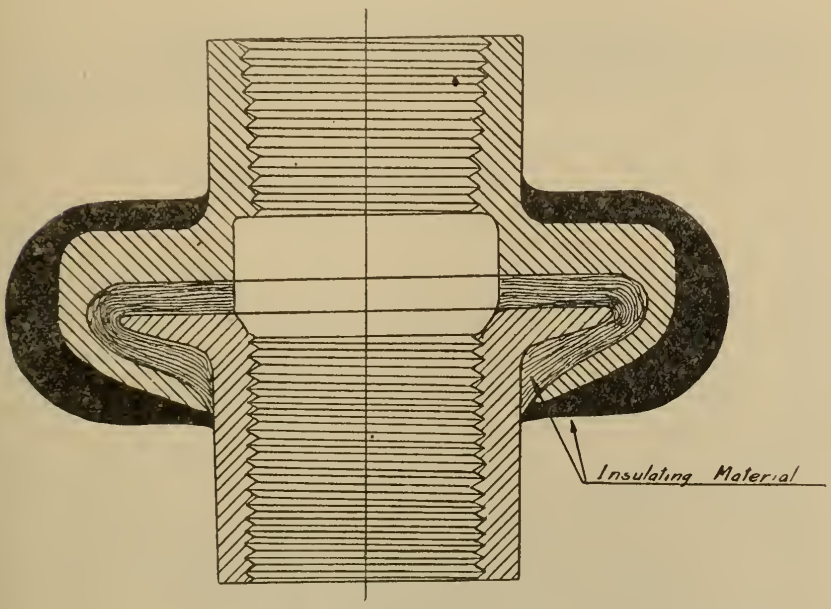


Fig. 13. Section of Macallen Insulating Joint for Service Pipe

for their first aim the reduction of the drop in potential in the rails to a minimum, because this removes the cause of the trouble. The first and most important step necessary to accomplish this is to maintain the rails perfectly bonded, so that the rails themselves form continuous electrical conductors. The next important step is to limit the radius from the power station to which the station supplies electric power, so that current does not have to be returned from excessive lengths of rail lines to any one power station. This is usually accomplished in practice by supplying power to electric railways from dis-

tributed substations. The next step is to remove the current from the rails wherever there is concentration of current, by means of insulated return feeders connecting from the rails at these points to the power station. In order that such insulated return feeders should be

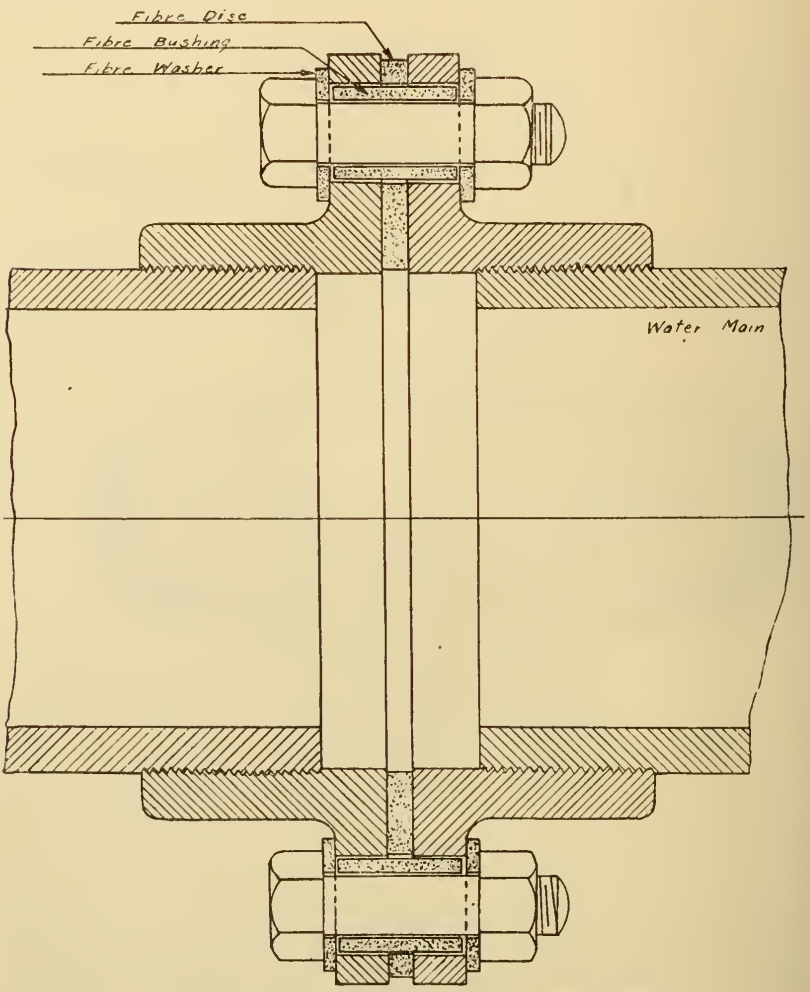


FIG. 14. SECTION OF INSULATING FLANGED JOINT FOR MAIN

most efficient in reducing drop in potential in grounded rails, these feeders should be proportioned for equal drop, so that the rails at all points where return feeders are connected are maintained at substantially the same potential under average load conditions.

This also requires that the rails immediately in front of the power station must not be connected directly to the negative bus-bar, unless a resistance corresponding to the average resistance of the return feeders is connected in the circuit. Where it is necessary to bring current back from a distant point in the rails, it is sometimes more economical to employ a negative booster in series with this return feeder rather than make this feeder of such large cross-section as would be required to maintain the distant point in the rails at the same potential as the nearer connection-points. With this system part of the voltage drop is actually removed from the rails and transferred to the insulated return feeders from which current cannot leak to ground.

An illustration of such an insulated return feeder system, proportioned for equal drop, is shown in Figure 15. In this illustration it is assumed that the negative bus-bar is at zero potential, and that

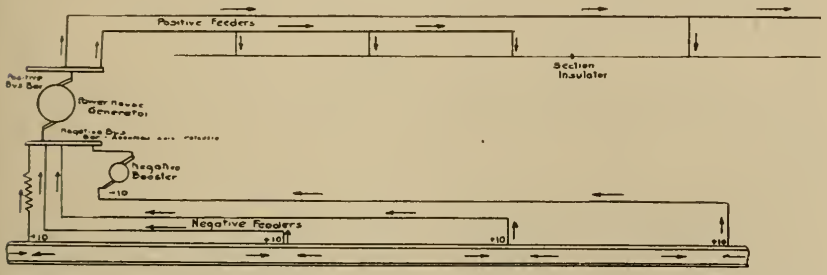


Fig. 15. Diagram of Single-Trolley Railway With Insulated Return Feeders and Negative Booster Showing Path of Currents and Assumed Rail Potentials

the return feeder connection-points on the rails are maintained at a potential of 10 volts with reference to the negative bus-bar. Under these circumstances, there is no tendency for current to flow from the rails between points where feeders are connected to the rails. The drop of 10 volts in the return feeders has also been removed from the rails.

The possibilities in the way of reducing stray currents by means of properly proportioned insulated return feeders was clearly shown by Mr. George I. Rhodes, in a paper entitled "Some Theoretical Notes on the Reduction of Earth Currents from Electric Railway Systems by Means of Negative Feeders," published in the *Transactions of the American Institute of Electrical Engineers for 1907*. A few of the figures from Mr. Rhodes' paper are reproduced in

Figure 16 together with diagrams illustrating the application of these figures. It will be seen that with the negative bus-bar grounded through a ground connection of negligible resistance, in addition to being connected to the rails at the power station, the greatest amount of stray current is produced which is assumed unity for purpose of comparison. This is illustrated by Diagram A of Figure 16. Disconnecting the negative bus-bar from ground connections, but not from rails, reduces stray currents to one-fifth of their former value, as illustrated by Diagram B of Figure 16. Disconnecting the negative bus-bar from ground connections

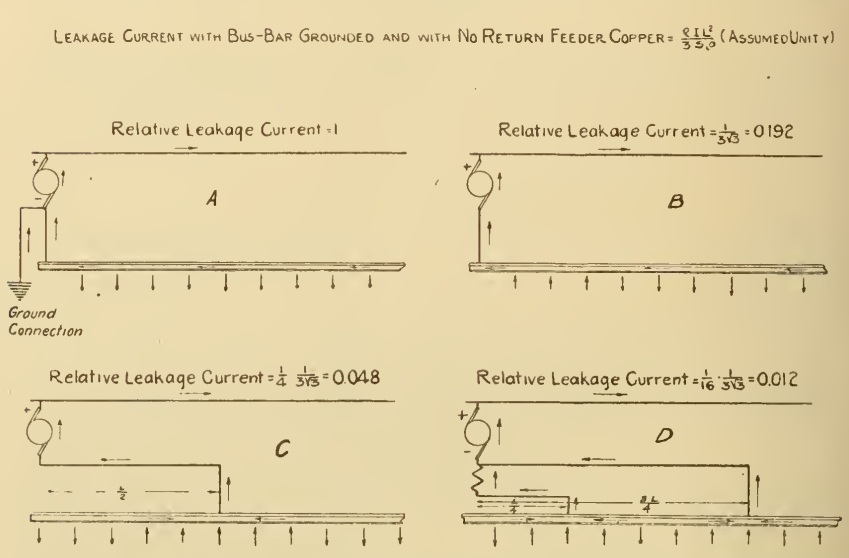

Leakage Current with Bus-Bar Grounded and with No Return Feeder Copper = $\frac{8}{3}\frac{IL^2}{S_c}$ (Assumed Unity)
Relative Leakage Current = 1
A
Ground Connection
Relative Leakage Current = $\frac{1}{5\sqrt{3}}$ = 0.192
B
Relative Leakage Current = $\frac{1}{4}\frac{1}{5\sqrt{3}}$ = 0.048
C
Relative Leakage Current = $\frac{1}{16}\frac{1}{5\sqrt{3}}$ = 0.012
D

Fig. 16. Relative Leakage Currents with Various Return Circuit Conditions

and from the rails at the power station, and returning the current by means of one insulated return feeder from the center of the line, reduces stray currents to 5 per cent of their former value, as illustrated by Diagram C of Figure 16. By using two insulated return feeders with the negative bus-bar insulated, the stray currents are reduced to 1.2 per cent of their former value, as illustrated by Diagram D of Figure 16. It therefore can be seen that very great reduction of stray currents can be accomplished by insulating the negative bus-bar at the power station from ground connections and from rails, and returning the current by means of insulated return feeders.

Since power stations are usually located near the center of load of an electric railway system, it is usual in cities to find railway lines radiating out from the power station. Where the running tracks are connected to the negative bus-bar only in the immediate neighborhood of the power station, these running tracks are depended upon alone to return current to the power station, and there is consequently always very great concentration of stray current under these circumstances in the neighborhood of the power station. Such railway lines radiating out from the power station are illustrated diagrammatically in Figure 17. In this figure eight railway lines are assumed radiating out from the power station. In the left-hand diagram of Figure 17 the rails of these lines are shown connected to the negative bus-bar at the power station only. It is seen that as the result of this, all of the current used on the eight railway lines flows in the rails towards the power station. The stray currents which leak from the rails to ground also concentrate in ground and on the underground piping in the neighborhood of the railway power station, where they must return to the rails to get back to the negative bus-bar.

If this connection between the negative bus-bar and the rails at the power station were removed, and the currents returned from the rails at points near the center of each railway line by means of insulated return feeders, as shown in the right-hand diagram of Figure 17, this concentration of current in the neighborhood of the power station would be entirely removed. With this arrangement, the current used by each individual line would tend to flow away from the rails at points away from the center of each line, and towards the rails near the center of each line. It is therefore seen that there is only one-eighth of the current returning from the rails at any one point than there is when the rails are connected to the negative bus-bar only at the power station. Further, the total stray current through ground with the conditions shown in the right-hand diagram will be only one-fourth of the total stray current with the conditions of the left-hand diagram, assuming similar soil conditions, so that at any one point the danger from electrolysis will be one-thirty-second of what it is in the neighborhood of the power station with the first arrangement. As a matter of practice, however, the actual reduction is very much greater, because the return feeder connection-points on the rails can be chosen so as to be located where the ground is high and dry, and consequently of high resistance, while the railway power station is generally located near water, where the ground is wet and of low resistance. Instead of connecting one insulated return feeder to

the middle point of every line, as indicated in Figure 17, a number of such feeders may be connected to a number of properly selected points in every line. In this way the drop in the rails and consequently also the stray current produced can be reduced to any desired value.

The reduction of drop in potential in rails, for the purpose of minimizing electrolysis, is the basis for various regulations and ordinances which have been enacted for the purpose of protecting underground metallic structures from electrolysis. For example, the well known English Board of Trade Regulations limit the maximum allowable potential difference between any two points in the rails to 7 volts. In Germany, a joint committee representing the electric railway, gas and water interests, has adopted a regulation limiting the average allowable potential difference between any two points in the rails to 2.5 volts within a district encircling the urban district by a radial distance of 2 kilometers. Beyond this circle, the average potential drop in the rails must not exceed 1 volt per kilometer.

Where railway return circuit improvements have been made to such an extent that there are no longer any excessive drops in the grounded rails, it is generally found that stray currents on underground pipes are reduced to small and often negligible amounts. Where, however, stray currents which are considered to be too large for safety are still found on such underground pipes after the railway return circuit has been thoroughly improved, then it is frequently possible and feasible to apply one or more of the other remedial measures, such as insulating joints in the pipes to take care of the small remaining stray current. Such other remedial measures, as bonding or insulating joints in pipes, must however never be applied unless the railway return circuit has been improved sufficiently to eliminate all excessive drops in the grounded rails.

SUMMARY AND CONCLUSIONS

Experience shows that where there is serious trouble from electrolysis caused by large stray currents leaking from street railways, the bulk of this trouble is due to defective rail bonding, to ground connections from the negative bus-bar, and to lack of return feeders to bring current back from the rails to the power station. While stray currents can only be entirely eliminated by insulating the return circuit by the use of a double trolley, either overhead or in conduit, it is nevertheless a fact which is not generally appreciated, that where large stray currents exist, these can always be reduced to a small

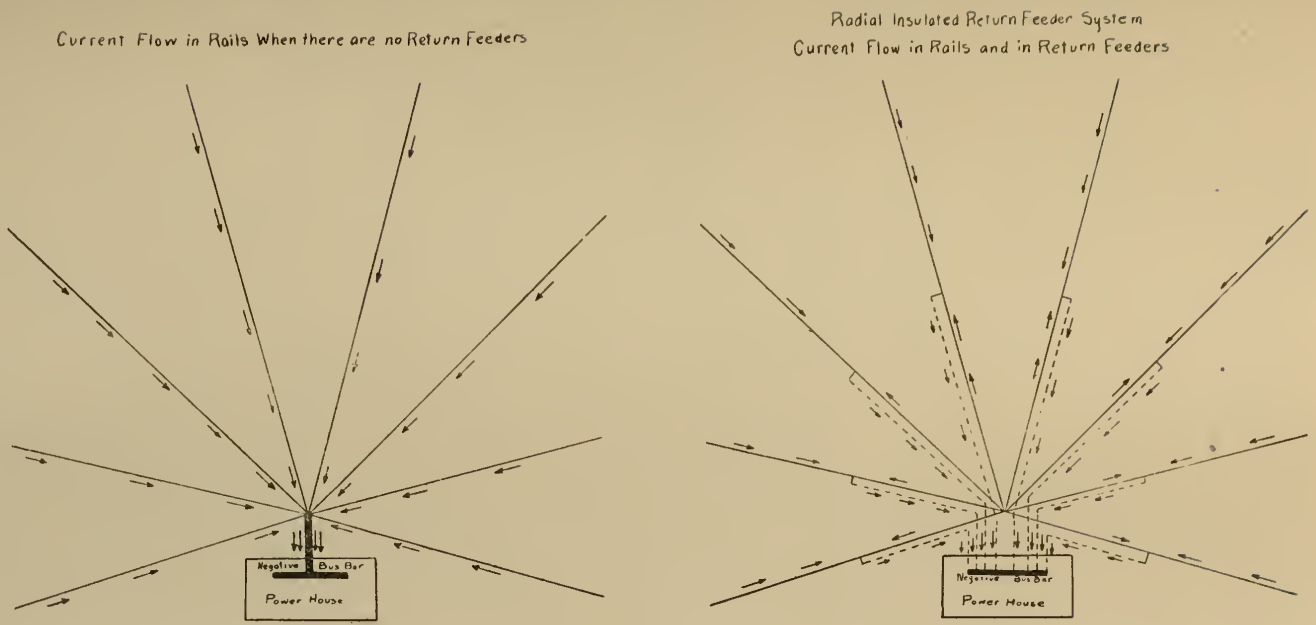

Current Flow in Rails When there are no Return Feeders
Negative Bus Bar
Power House
Radial Insulated Return Feeder System
Current Flow in Rails and in Return Feeders
Negative Bus Bar
Power House

FIG. 17. DIAGRAMS SHOWING TROLLEY LINES RADIATING OUT FROM POWER STATION WITH AND WITHOUT INSULATED RETURN FEEDERS AND SHOWING PATH OF RETURN CURRENTS

fraction of their present value by removing all ground connections of the negative bus-bar, and installing insulated return feeders proportioned for equal drop from radially disposed points in the track system located at some distance from the power station. By this method the rails are drained of current and any desired part of the voltage drop can be removed from the rails and transferred to insulated conductors from which currents cannot leak. In Europe, such radial insulated return feeders for bringing current back from the rails to the power station are made necessary by regulations limiting the allowable drop in voltage in the rails, and in most cases such installations of insulated return feeders have substantially removed serious trouble from electrolysis. This system of minimizing stray currents by means of radially disposed insulated return feeders has also been installed in a number of American cities, and the method is gradually being recognized as by far the best for minimizing stray currents. This system in fact removes the root of the trouble, by draining the rails of current and removing voltage drop from the rails and thus preventing substantial leakage of current through ground, and is therefore correct in principle. The railroad companies frequently object to this system claiming that it is prohibitively expensive. This is certainly not the case, as is evidenced by the fact that the method is in general use in Europe and in a number of American cities today. The fact is that in many electric railways there is practically no installation of negative feeders and the railway companies are often not willing to install even a moderate amount of return feeder copper. A mistake is often made in confusing the radial insulated return feeder system with paralleling the rails with copper. Of course where the negative bus-bar is connected to the rails at the power station, and these rails are paralleled with copper feeders, the drop in the rails is reduced in the proportion that the conductivity of the return circuit is increased, but no part of the drop is actually removed from the grounded rails. The amount of copper paralleling the rails that would be required to reduce stray currents to a negligible amount would in all large systems be absolutely prohibitive. This however is not the case with the radial insulated return feeder system. With the latter system any desired reduction in rail drop and consequently in the amount of stray current can be secured, independent of the amount of copper installed, the amount of copper being determined by the allowable drop or power loss in the return circuit. The railway company can divide the annual charge of interest on copper invested and operating expense in any ratio within wide limits without

affecting the amount of stray current produced from the system. The pipe-owning companies suffer constant expense on account of stray railway currents in the form of repairs and depreciation of their underground structures, and in the form of liability for accidents, and this can be reduced with certainty to any desired extent, short of complete elimination, by the assumption on the part of the railway company of expense in the form of interest and power charges for its return circuit. The railway companies should in all fairness assume this expense and responsibility. If the railway companies would apply as much engineering knowledge and money to their negative circuits as they do to their positive circuits there would be but little trouble from electrolysis. The pipe-owning companies should coöperate with the railway companies by affording them access to their pipes for making necessary measurements, etc. After a railway company has installed a reasonable and fair return circuit, it sometimes happens that it is desirable to eliminate any remaining current on pipes by the use of properly located insulating joints. Under these circumstances the pipe-owning companies should be willing to coöperate with the railway company in the installation of such joints.

In the decree recently filed in the celebrated Peoria case, the railway company is enjoined and restrained from injuring the property of the water company by electric current escaping from the rails or structures of the railway company. No particular method for preventing escape of current is prescribed in the decree, because the court in its decision has already stated that a court does not have the power to prescribe by injunction any specific system, and that this power resides only with legislative bodies. In its decision the court however lays great stress upon the insulated radial return feeder system, which is spoken of as a quadrilateral system. The decree also requires the water company to coöperate with the railway company to the extent of giving the railway company access to its piping system for the purpose of measuring flow of current upon its system, and of determining whether injury from electrolysis is being continued, in order that the railway company may determine whether it is complying with the terms of the decree. It is evident from this decree that the expense of providing a proper return circuit for the railway system so as to minimize escape of current falls entirely upon the railway company as it should in all fairness. One section of the decree states that within six months after the expiration of one year after the date of the decree, the railway company may apply for a hearing on the question whether it should be permitted to

make an experimental use of the drainage system, in order to ascertain whether such drainage or limited use thereof can be practically applied to the piping system.

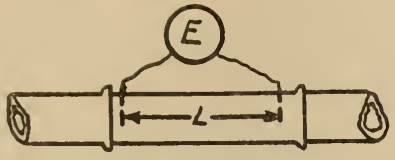
It appears from the decision and the decree that the railway company must within one year improve its return circuit so as to prevent as much as possible the escape of stray electric currents from its systems. If, after this has been done, it is found that stray currents still exist on the piping system, then the railway company may apply to the court for a hearing to determine whether the water company should be directed to permit the railway company to try a drainage system as an experiment to remove the remaining current harmlessly. A drainage system such as contemplated as a possible final measure by the Peoria decree, when properly controlled so that only small currents are drained from the pipes, does not have the objectionable and dangerous features of promiscuous bonding where large currents are made to flow on the pipes as often found in American cities, and may even be a safe final method where the soil conditions are favorable and where the underground structures are all continuous electrical conductors. It nevertheless seems to the author very unfair that any pipe-owning company should be compelled by a court order to permit an electric railway company to use its pipes as a return conductor for its railway system, even to the slightest extent. If the court does not have the power to compel the railway company to adopt any specific method for eliminating the danger from electrolysis, then it certainly should not impose any specific method upon the pipe-owning companies. The latter may for example prefer to remove any small remaining stray currents by means of properly located insulating joints.

It is the author's firm conviction that such remedial measures as pipe drainage or insulating pipe joints should be used if at all only as a final measure and never until the return circuit of the railway has been improved so that only small amounts of stray current remain on the underground structures. This view appears to be entirely in accord with the Peoria decision, and is certainly in accord with the best engineering practice.

TABLE FOR DETERMINING CURRENT FLOW ON IRON PIPES FROM MILLIVOLT DROP ALONG CONTINUOUS LENGTH OF PIPE

Computed by Albert F. Ganz, M.E.

L = Distance between contacts, feet.
E = Instrument reading, millivolts.
K = Constant from table.
Current flow, amperes = $\frac{KE}{L}$
Wires must not span joint.



Cast-Iron Water Pipe

American Water Works Association Standard—Adopted 1908. Weight 1 cubic foot = 450 pounds

Resistance 1 pound-foot = 0.00144 ohm

DESIGN	NOMINAL DIAM. OF PIPE	WEIGHT PER FOOT EXCLUSIVE OF BELL	RESISTANCE PER FOOT EXCLUSIVE OF BELL	K CURRENT FOR 1 MILLIVOLT DROP PER FOOT OF CONTINUOUS PIPE
	ins.	*lbs.*	*ohm*	*amps.*
100 feet head, 43 pounds pressure	4	18.1	0.0000795	12.6
	6	27.9	0.0000516	19.4
	8	38.8	0.0000371	27.0
	10	52.1	0.0000276	36.2
	12	67.1	0.0000215	46.6
	14	82.5	0.0000175	57.3
	16	99.0	0.0000146	68.7
	18	118.	0.0000122	82.0
	20	138.	0.0000104	95.8
	24	187.	0.0000077	130.
	30	267.	0.00000539	185.
	36	359.	0.00000402	249.
	42	465.	0.00000310	323.
	48	609.	0.00000236	423.
	54	733.	0.00000196	509.
	60	838.	0.00000172	583.
	72	1170.	0.00000123	813.
	84	1450.	0.000000994	1010.
200 feet head, 86 pounds pressure	4	20.1	0.0000716	14.0
	6	31.2	0.0000462	21.6
	8	42.7	0.0000337	29.7
	10	59.0	0.0000244	41.0
	12	76.6	0.0000188	53.3
	14	95.0	0.0000152	66.0
	16	115.	0.0000125	79.9
	18	138.	0.0000104	95.9
	20	163.	0.00000884	113.
	24	218.	0.00000661	151.
	30	313.	0.00000460	217.
	36	419.	0.00000344	291.
	42	544.	0.00000265	378.
	48	689.	0.00000209	479.
	54	847.	0.00000170	588.
	60	1010.	0.00000143	702.
	72	1420.	0.00000101	986.
	84	1880.	0.000000767	1310.
300 feet head, 130 pounds pressure	4	21.3	0.0000676	14.8
	6	33.0	0.0000436	22.9
	8	48.1	0.0000300	33.4
	10	65.6	0.0000219	45.5
	12	85.6	0.0000168	59.5
	14	108.	0.0000133	75.0
	16	134.	0.0000107	93.1
	18	163.	0.00000884	113.
	20	191.	0.00000754	133.
	24	258.	0.00000558	179.
	30	368.	0.00000392	256.
	36	498.	0.00000289	346.
	42	659.	0.00000218	458.
	48	834.	0.00000173	579.
	54	1040.	0.00000138	723.
	60	1220.	0.00000118	847.
	72	1750.	0.000000823	1220.
400 feet head, 173 pounds pressure	4	22.8	0.0000631	15.8
	6	35.4	0.0000407	24.6
	8	51.2	0.0000282	35.6
	10	71.6	0.0000202	49.7
	12	93.9	0.0000153	65.2
	14	119.	0.0000121	82.6
	16	148.	0.00000973	103.
	18	179.	0.00000805	124.
	20	213.	0.00000676	148.
	24	286.	0.00000503	199.
	30	422.	0.00000342	293.
	36	583.	0.00000247	405.
	42	765.	0.00000188	532.
	48	962.	0.00000150	668.
	54	1230.	0.00000117	854.
	60	1460.	0.000000987	1014.
500 feet head, 217 pounds pressure	6	37.8	0.0000381	26.2
	8	56.7	0.0000254	39.4
	10	78.9	0.0000182	54.7
	12	104.	0.0000138	72.2
	14	133.	0.0000108	92.4
	16	165.	0.00000873	115.
	18	203.	0.00000710	141.
	20	241.	0.00000598	167.
	24	329.	0.00000438	228.
	30	481.	0.00000300	334.
	36	668	0.00000216	464.
600 feet head, 260 pounds pressure	6	39.6	0.0000364	27.5
	8	60.7	0.0000237	42.2
	10	84.7	0.0000170	58 9
	12	113.	0.0000127	78.5
	14	146.	0.00000987	101.
	16	181.	0.00000795	126.
	18	220.	0.00000654	153.
	20	266.	0.00000541	185
	24	362.	0.00000398	251
	30	539.	0.00000267	375.
	36	754.	0.00000191	523

TABLE FOR DETERMINING CURRENT FLOW ON PIPING FROM MILLIVOLT DROP ALONG CONTINUOUS LENGTH OF PIPE—Continued

Cast-Iron Gas Pipe American Gas Institute Standard—Adopted 1911 Weight 1 cubic foot=450 pounds Resistance 1 pound-foot = 0.00144 ohm				Standard Wrought-Iron Pipe Resistance 1 pound-foot = 0.000181 ohm				Standard Steel Pipe Resistance 1 pound-foot = 0.00021 ohm			
Nominal diam. of pipe	Weight per foot exclusive of bell	Resistance per foot exclusive of bell	K current for 1 millivolt drop per foot of continuous pipe	Nominal diam. of pipe	Weight per foot	Resistance per foot	K current for 1 millivolt drop per foot of continuous pipe	Nominal diam. of pipe	Weight per foot	Resistance per foot	K current for 1 millivolt drop per foot of continuous pipe
ins.	*lbs.*	*ohm*	*amps.*	*ins.*	*lbs.*	*ohm*	*amps.*	*ins.*	*lbs.*	*ohm*	*amps.*
4	17.3	0.0000833	12.0	⅛	0.24	0.000754	1.33	⅛	0.24	0.000873	1.14
6	27.3	0.0000528	19.0	¼	0.42	0.000431	2.32	¼	0.42	0.000500	2.00
8	38.0	0.0000379	26.4	⅜	0.56	0.000324	3.09	⅜	0.56	0.000376	2.66
10	51.1	0.0000282	35.5	½	0.84	0.000216	4.64	½	0.84	0.000250	4.00
12	67.1	0.0000215	46.6	¾	1.12	0.000162	6.18	¾	1.12	0.000188	5.33
16	102.	0.0000141	70.9	1	1.67	0.000108	9.23	1	1.67	0.000126	7.95
20	140.	0.0000103	97.1	1¼	2.24	0.0000808	12.4	1¼	2.24	0.0000937	10.7
24	187.	0.00000770	130.	1½	2.68	0.0000676	14.8	1½	2.68	0.0000784	12.8
30	258.	0.00000559	179.	2	3.61	0.0000501	20.0	2	3.61	0.0000582	17.2
36	346.	0.00000416	240.	2½	5.74	0.0000316	31.7	2½	5.74	0.0000366	27.4
42	453.	0.00000318	314.	3	7.54	0.0000240	41.7	3	7.54	0.0000278	35.9
48	609.	0.00000237	423.	4	10.66	0.0000170	58.8	4	10.67	0.0000197	50.8
				6	18.76	0.00000965	104.	6	18.76	0.0000112	89.4
				8	28.18	0.00000643	156.	8	28.18	0.00000745	134.
				10	40.00	0.00000452	222.	10	40.07	0.00000524	191.
				12	49.00	0.00000370	271.	12	49.00	0.00000428	234.

DISCUSSION

Mr. Edward Wegman: In a recent report of the metropolitan water board of Boston the speaker read that they had tried to stop electrolysis by putting wooden joints in a pipe line, using one about every 100 feet. Would an insulated joint of that kind stop electrolysis, or would the current go around the joint and through the soil?

Professor Ganz: That depends upon the soil; if it is in dry soil of high resistance it would probably stop it; if it is in wet soil of low resistance there would be a good deal of shunting action.

A Member: Would there be any difference in using insulating joints in a water pipe as compared with such joints in a gas pipe, on account of the conductivity of the water.

PROFESSOR GANZ: No; as pure water has an enormously high resistance compared with iron.

A MEMBER: The speaker would like to ask the Professor how far they run out those insulated return feeders from the rails to the power station?

PROFESSOR GANZ: That depends upon the extent of the railway system and particularly upon the radius over which one power station supplies power for the electric railway. Taking it on the average it might be anywhere from a half mile to one or two miles. In the particular system referred to the average distance was about three quarters of a mile.

MR. E. H. BREIDENBACH: Would you tap one feeder in two or three different places?

PROFESSOR GANZ: No; we would run a separate feeder to each point.

MR. A. A. REIMER: Professor Ganz has referred to the fact that the greatest damage comes from direct current and we are all probably more familiar with damage from such current than with any other, but during the past two or three years we have been having considerable trouble from alternating currents used for light and power. The neutral wire, even though grounded properly, does not seem to accomplish all that it is supposed to accomplish, due probably to defective work at some unseen point. For instance, one case that has recently come to our attention shows the almost complete destruction of a bronze stop cock by grounded alternating current, the core of the stop cock being almost completely melted out. This is the most severe case which we have had, but only strengthens our position in our fight against the light and power companies using alternating current. We are now seeking to prevent absolutely the grounding of any such current on to our water pipes. Perhaps others may not have had this experience, but we feel strongly on this point in view of the damage that has already occurred. Probably all of us know of cases where more or less severe shocks have been received by occupants of houses because of grounded light or power wires, some of these cases having resulted fatally.

Professor Ganz also spoke of the fact that electrolysis occurred in what he called the negative district, referring to his diagram showing the directions of flow of the return current. The point should be made clear that the negative term applies only to the earth, the current being actually positive so far as the pipe is concerned. The condition was shown all right on the screen, but the statement sounded as though we were actually getting electrolytic corrosion by a negative current.

Referring to the question of electric drains, the speaker feels rather diffident about taking issue with Professor Ganz after his most excellent paper and after his rather severe condemnation of those of us who have gone into the matter of electric drains to the point of actually installing some of these devices. The speaker's experience includes both sides of this question on electrolysis. For several years he was in the street railway work and therefore was connected intimately with the offending corporation, but for the last seven years he has been in the water works business and realizes how heavy is the damage done through stray currents, especially to water pipes. In spite of this experience the speaker still is one of those who will place electric drains on our system, foolish though the Professor may call him, though not for one moment claiming that this method is in any way superior to or even the equal of the double overhead trolley system. The speaker's reason for advocating the placing of such drains is that this method offers the best temporary relief that can be obtained at the present time and the one which can be forced on the offending companies. He adopted the electric drain method of relief only after a very careful investigation and after realizing that it was practically impossible to obtain a double overhead trolley system in our city, the street railway system serving East Orange being a portion of a system comprising about four hundred miles of track.

The speaker was satisfied with the installation of the drains as accomplishing the purpose for which they were intended, the relieving of a long line of pipe of a heavy current and concentrating this current into a few well defined points. We placed large drains because we were carrying considerable current. Our mains, services and stop cocks had been destroyed and we had become thoroughly tired of making repairs along these lines, even though the offending company paid the bills for such work. The annoyance caused our customers, as well as ourselves, was not paid for by the payment for the actual work and material involved in making the repairs so we

adopted this system of drains and since that time have had no further apparent trouble along the mains so protected. We further protect ourselves by occasional surveys of the districts drained to see whether damage is occurring at new points. The speaker is not claiming that no damage is occurring along these lines, but does claim that the damage has been reduced to a great extent, the potential differences now existing being very small, actually fluctuating in a number of cases from positive to negative.

The speaker thinks Professor Ganz is entirely correct in condemning the electric drain method as a general practice and in advocating the double overhead trolley system, but he believes we are fairly safe in using the drainage method if a proper watch is kept to detect new danger or damage and for that reason believes the drainage method should not be absolutely condemned. It may be even considered a very favorable adjunct for the majority of cities, if used only as a a relief measure and not considered a permanent scheme for the removal of damaging current. Other methods may be better, as for instance the minimizing scheme mentioned by Professor Ganz. This method is certainly excellent and if we can get it we certainly should do so, but if we cannot get that and wish to stop the damage before complete destruction of our system is accomplished, by all means let us adopt the alternative drain method, protect ourselves by actual surveys, which can be made at small expense by our men, in order to detect new points of damage, and then keep up the fight for the absolute removal of the damaging current through the double overhead trolley system or some other device which can accomplish the same result.

Professor Ganz: Referring to the case of electrolysis from alternating current mentioned by Mr. Reimer, it looks as though the destruction of the stop cock which is stated to have been "melted out" is a case of destruction by electric arcing caused by accidental grounding of one of the circuit wires rather than a case of destruction by electrolytic action. The speaker has no doubt that alternating currents on piping caused by accidental grounds can give considerable trouble from burnouts and from shocks. He does not believe however that you could get electrolytic action from the grounding of an alternating current lighting system to water pipes under any ordinary conditions. Mr. Reimer also speaks of the reference to electrolysis in what the speaker calls a negative district. The speaker has used the term "negative district," as it is ordinarily employed to desig-

nate a district in which the pipes are negative in potential to the trolley tracks. Of course the pipe is positive in potential to the surrounding soil as otherwise current could not flow from the pipe to the ground.

Regarding pipe drainage as a measure of temporary relief recommended by Mr. Reimer, the speaker can say that where a piping system is small such a scheme can be used in some cases where the conditions are favorable with more or less satisfactory results. Surveys consisting of potential measurements between pipes and rails do not however afford proof of the safety of the system, as dangerous potential differences may exist between parts of the same piping system or between the piping system and other metallic structures; these will not be found by such surveys and in fact can hardly be found by test. The speaker knows of at least one large piping system where electrical drains were tried and so much other trouble was experienced that this system was entirely abandoned, he firmly believes that it is far better to apply a method which actually reduces stray currents and not increases them as is always the result of drainage methods. Where a pipe owning company permits drainage connections to be made to its pipes the result generally is that the railway company will do absolutely nothing to improve its return circuits with a view of minimizing escape of currents. The speaker believes it is far safer and wiser for a pipe owning company to refuse absolutely to allow the railway company to make connections to its pipes, and to insist that the railway company make improvements in its return circuit that will at least reduce escape of current. He feels very certain that if the various pipe owning companies would coöperate they could by united effort compel the railway companies to practically reduce stray currents to negligible amounts by properly installed insulated return feeders as is common practice in European electric railways and as is done in some American electric railways.

WATER SOFTENING AT OWENSBORO, KENTUCKY

By E. H. Breidenbach

In the year 1878, a private corporation, Owensboro Water Works Company, built a plant to furnish Owensboro with water. The supply was drawn from the Ohio River. As is well known, the Ohio, during about eight months in the year is muddy, and during every month of the year is unclean from an organic standpoint.

From 1878 to 1906 the Owensboro Water Works Company furnished this muddy and unclean water to the people of Owensboro. The rules which the company established were arbitrary, and the charge for water exorbitant. These conditions became so intolerable that a bond issue of $260,000 was voted to build a municipal water plant. The plant was built and completed in 1906. It is located just east of the city of Owensboro on ground 25 feet above the Ohio River at high water mark. The water, which is drawn from deep wells, is clear and colorless; upon standing, a small amount of iron oxide settles out. Originally there were 13 wells; now there are 18. The water filters through a water bearing stratum of sand rock, which lies 125 feet to 250 feet below ground level. The wells in use are pumped by compressed air directly into the softener; after purification the water is delivered by gravity into two 1,000,000 gallon reservoirs.

While the municipal water plant was under construction, the Owensboro Water Works Company improved the quality of its water by straining it through a sand bar in the bed of the Ohio River instead of drawing it directly from the stream, and though this clarified the water to some extent, yet, at times, and especially in recent years, this filtered water has carried considerable amounts of suspended matter.

On the completion of the municipal water plant, a majority of the patriotic householders of Owensboro commenced to patronize it; but the large water users, the railroads and factories, continued to use water from the private company because that water was much softer than the well water from the municipal plant. The patrons of the city well water soon discovered that it was considerably harder than

the old company's water which they had become accustomed to using, and some of them returned to the old company.

This brought about vigorous competition between the municipal plant and the old company; and at once it became apparent to the Board of Electric Light and Water Commissioners that if the municipal plant was to be commercially successful, a softer water must be furnished its patrons.

Early in 1911, the Board of Electric Light and Water Commissioners, and the Water and Light Committee of the City Council, employed consulting engineers, and they drew plans for a proposed water softening plant for the city. Thereafter, in June of the same

FIG. 1. COMPLETE PLANT LOOKING NORTHWARD

year, the city entered into a contract for the excavation, concrete, and building work, and for the mechanical and operating equipment for a water softener.

The softening plant was put into operation in December, 1911. Its construction is very simple, and it may be said to operate automatically. One man on each shift does all the necessary labor.

The water softener proper consists of three fundamental features comprising: (a) Chemical tanks and regulator, (b) Softening tanks for mixing raw water and purifying chemicals, (c) Sedimentation basins.

The water is piped from the wells directly into the softener. It enters through the inlet weir box between softening tanks 1 and 2, and passes through the three Sutro weirs of 1,000,000 gallons per day

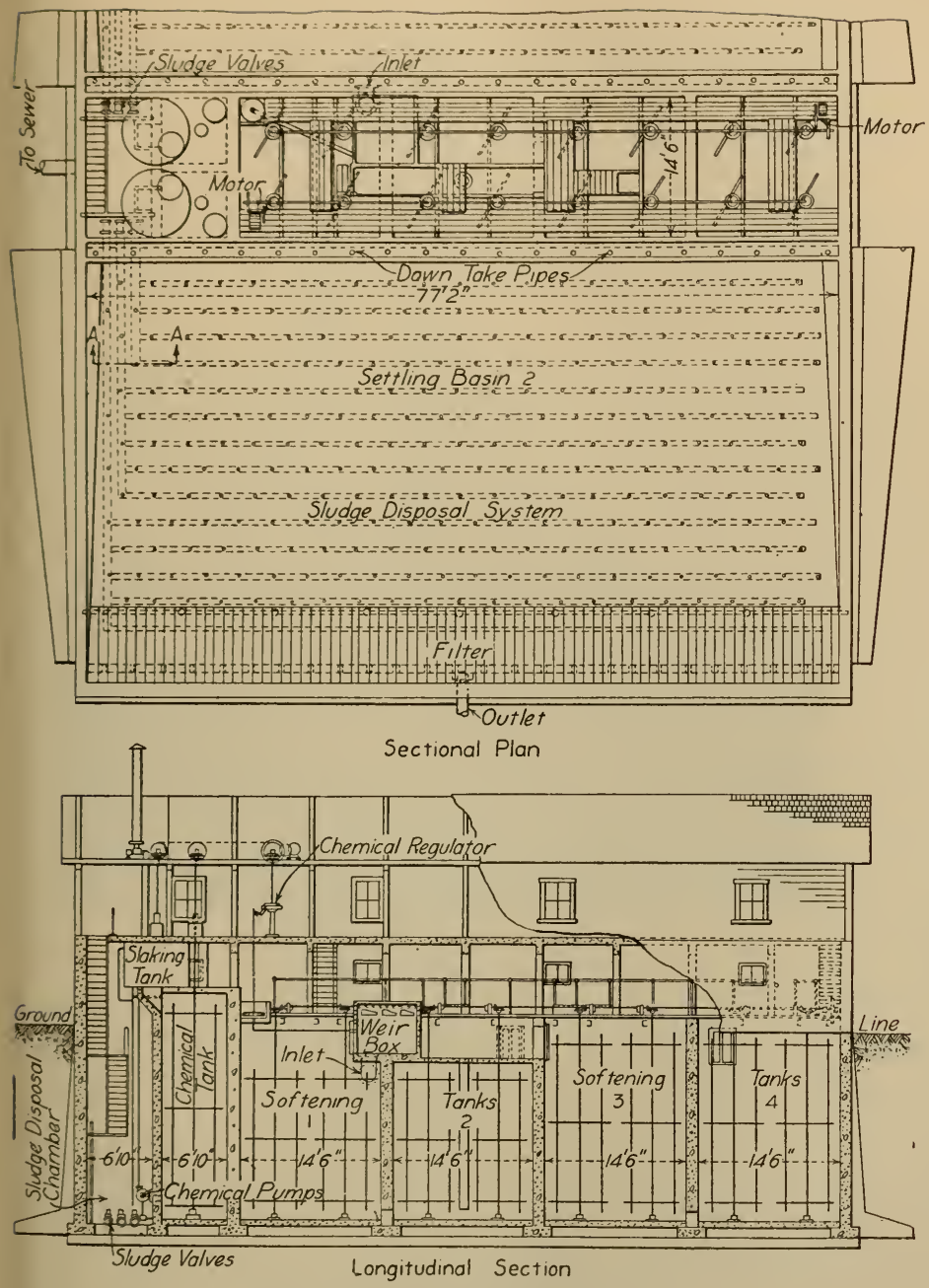


FIG. 2. GENERAL DRAWING OF PLANT

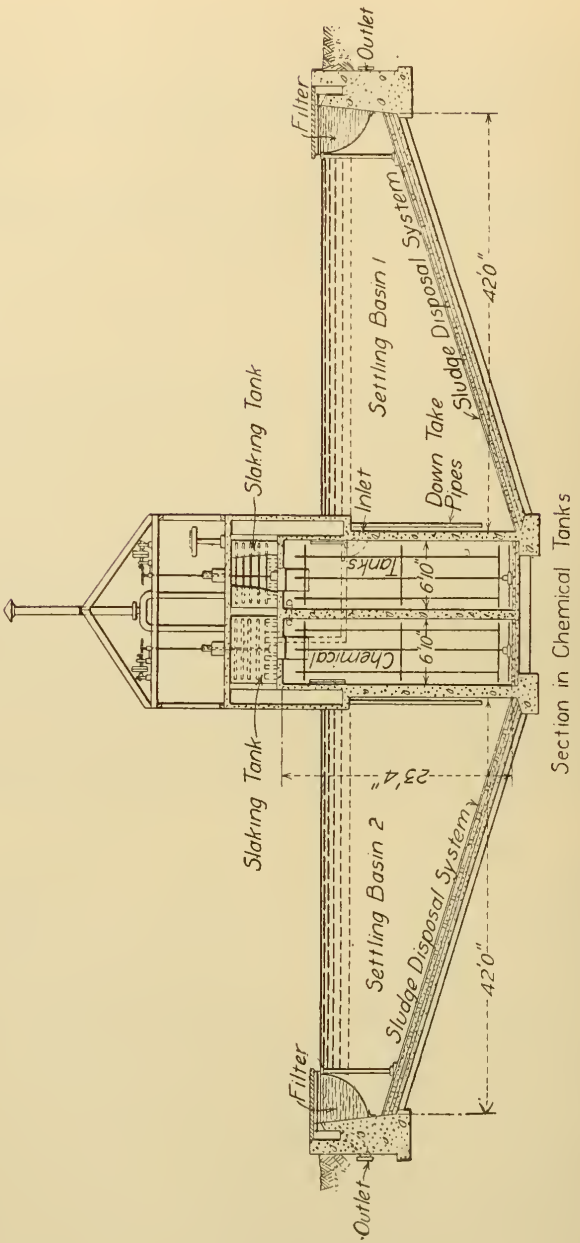


FIG. 3. TRANSVERSE SECTION

capacity each, and into softening tank No. 1 (see Fig. 2). By reference to the longitudinal section, it will be noted that the flow in softening tank No. 1 is downward, thence through an opening in the base of the partition wall between Nos. 1 and 2, upward in No. 2, thence through a sluice gate into No. 3, downward in No. 3 and into the lower portion of No. 4, thence upward to the sluice gates (marked 3 and 4) at each side of the softening tank No. 4. When operating at rated capacity, the water takes one hour to pass from the inlet of softening tank No. 4 to the outlet of No. 1. The arrangement of softening tanks, sluice gates, agitators, etc., is such that the plant

Fig. 4. West Basin Before Filling

can be operated as a single unit, or as two distinct units, either simultaneously or separately.

The chemicals used in the purification, namely, lime and soda, are applied at the top of softening tank No. 1. During its flow through the softening tanks the mixture of water and chemicals is subjected to continual agitation, supplied by four sets of agitators; each set consisting of four agitators. These sixteen agitators are driven from two shafts; the power is furnished by two 2 h.p. back geared electric motors. As one motor furnishes sufficient power to drive all of the agitators, the extra motor is kept in reserve.

From softening tank No. 4, the water is distributed through the sluice gates, into distributing channels shown on the cross-sectional view (Fig. 2). The outlet passages from each of the distributing channels consist of 21 spiral riveted downtake pipes. These deliver the water to the lower portion of each of the settling basins. The flow in the settling basins is outward toward the excelsior filters, one of which is shown (Fig. 4).

During the flow across the settling tank, practically all of the precipitate settles out, so that the excelsior filters, reached just before the water passes to the outlet, have but little work to do.

The accompanying table shows the composition of the water before softening. For convenience in comparison, the analysis of the softened water is also included.

Municipal water softening plant, Owensboro, Ky. Samples taken January 1, 1912

	RAW WATER	SOFTENED WATER
Calcium carbonate	9.52	2.61
Magnesium carbonate	4.25	
Magnesium sulphate	0.09	
Magnesium hydroxide		0.81
Iron oxide, Alumina	0.18	0.06
Silica	0.46	0.39
Suspended matter	0.90	
Incrusting solids	15.40	3.87
Sodium sulphate	2.22	1.81
Sodium chloride	0.89	1.03
Sodium hydroxide		0.30
Non-incrusting solids	3.11	3.14
Free carbon dioxide	0.51	
Half bound carbon dioxide	6.41	
Volatile matter	6.92	

Results expressed in grains per United States gallon.

In the purification there is used 1645 pounds of lime and $16\frac{1}{2}$ pounds of soda per 1,000,000 United States gallons. The chemicals are purchased and delivered at the softener at the following prices: Lime, $4.50 per ton; Soda, $20 per ton, making the cost of chemicals for purification $3.95 per 1,000,000 gallons.

The chemicals before use are stored on the second floor of the main building. They are conveyed by hand truck from the scales to the charging room. In practice, 2000 pounds of lime at a charge is slaked

in each of the steel lime slaking tanks, which are located immediately beneath the charging floor (see Fig. 5).

There are two 2 h.p. electric motors connected to drive the agitators in the lime slakers, chemical tanks and chemical regulator. As one motor furnishes sufficient power, the other is held in reserve.

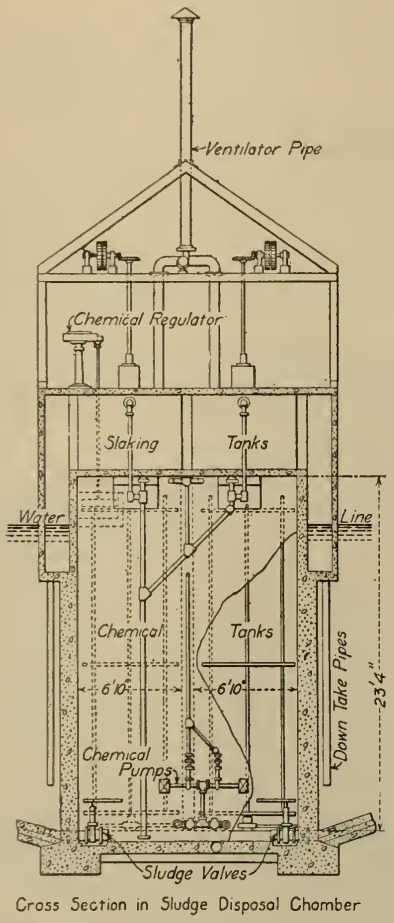


FIG. 5. SLAKING, CHEMICAL AND SOFTENING TANKS—CROSS SECTION

With the type of slakers in use, it is unnecessary to crush the lime. Lumps of the size as they come from the kiln are readily handled. Slaked lime is dropped into the chemical tanks below through a specially designed valve. After the slaked lime has been delivered into the chemical tank, the proper quantity of 58 per cent soda ash

is added and the solution made up to the desired strength. For the purpose of indicating the height of solution in the chemical tanks, the bottom of which is nearly 30 feet below the charging floor, a pneumatic mercury gauge is employed, by means of which the attendant

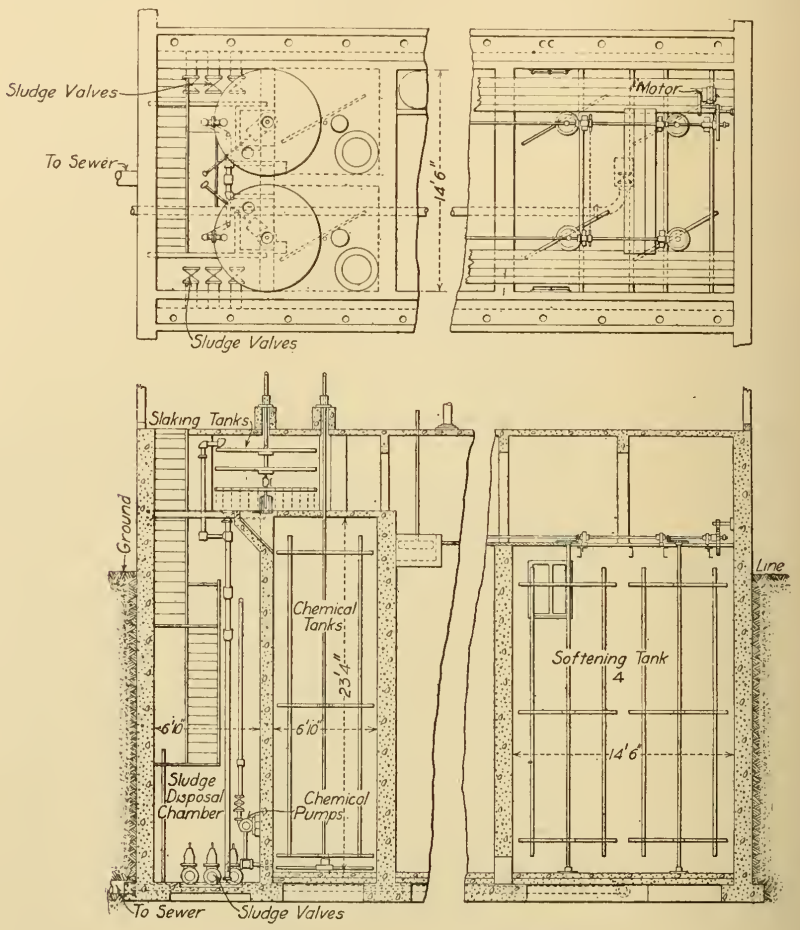


FIG. 6. SLAKING, CHEMICAL AND SOFTENING TANKS

can note the height of solution in the chemical tanks. Both the slaking and chemical tanks are in duplicate, although only one set is used at a time. When operating at about a 2,000,000 gallon per day rate, as at present, a charge of chemicals lasts thirteen to fifteen hours.

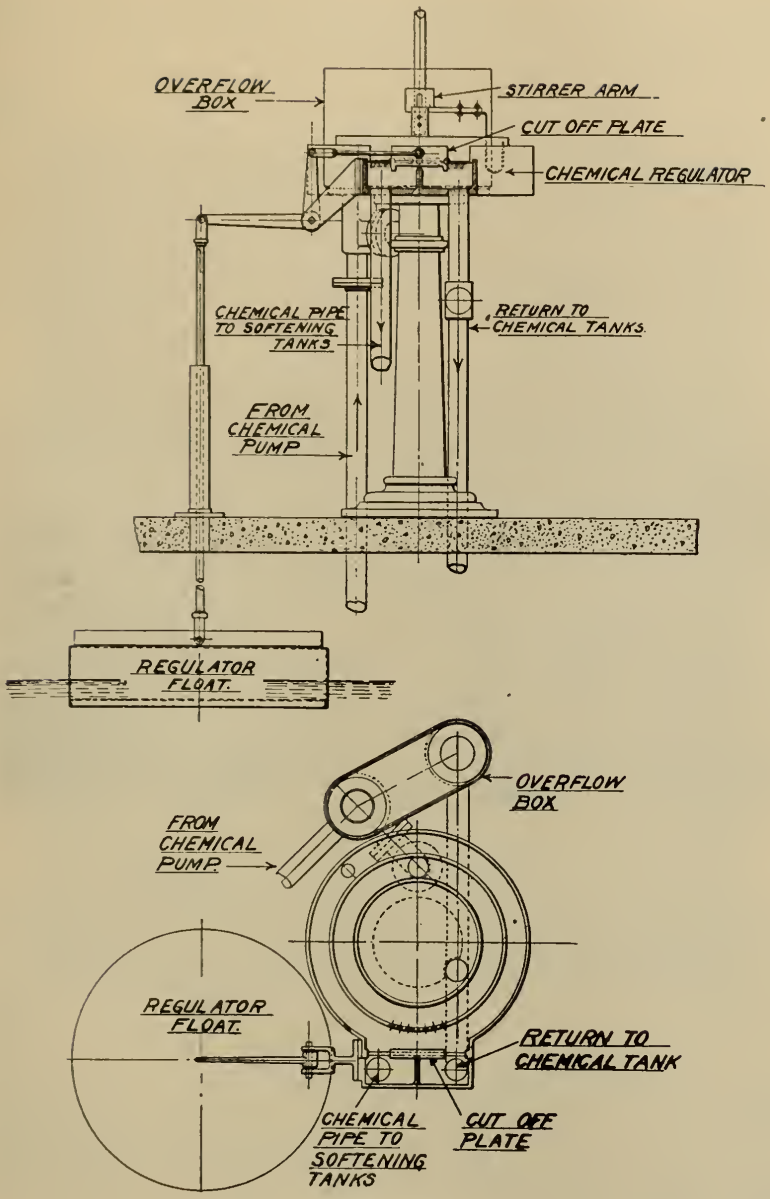


FIG. 7. CHEMICAL REGULATOR

The prepared chemical solution is delivered to the chemical regulator on the operating floor by direct connected centrifugal pumps taking their suction in the chemical tanks.

By means of the overflow box into which the solution from the chemical pumps is delivered, a constant flow of chemical solution is supplied into the regulator regardless of the varying head on the suction side of the centrifugal chemical pumps. The chemical regulator is of standard construction and its principle of operation involves the use of a laterally movable cut-off plate. The position and movements of this cut-off plate are controlled by a regulator float located in a basin on the inlet floor below. As shown (Fig. 6) the plant is operating at half capacity. Only one-half of the constant volume of

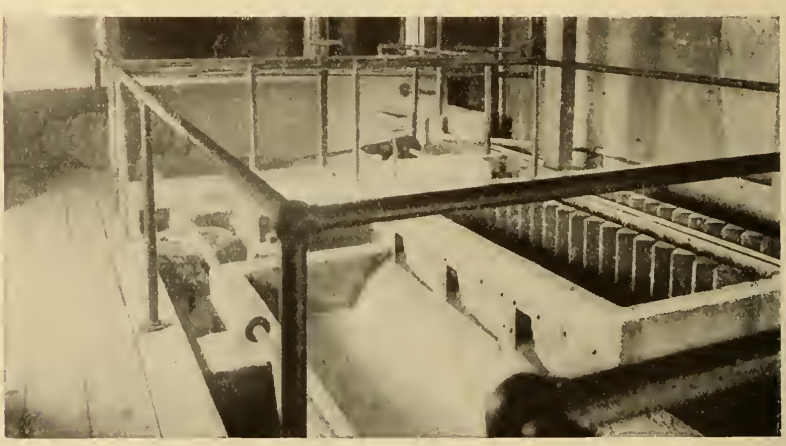


Fig. 8. Inlet Weir Box Showing Sutro Weirs

solution which passes over the regulator weir flows to the softening tanks, the other half being returned to the chemical solution tanks. The Sutro weirs are so constructed that the height of water flowing through them is in direct proportion to the quantity. Any increase in height of water level results in raising the regulator float which rides in a basin connected with the weir box. This movement of float causes proportional shifting of the cut-off plate so that more of the chemical solution flowing over the regulating weir will reach the softening tank and a correspondingly smaller quantity will be returned to the chemical tanks.

Figure 8 shows the inlet box with its three 1,000,000 gallons per day capacity Sutro weirs. The regulator float which controls the admission of chemical solution rides on the water in a basin in the

background. A connecting pipe transmits the fluctuation in height of water from the weir box to the float basin.

Figure 9 shows the chemical regulator with its operating links, bell crank, and laterally movable cut-off plate.

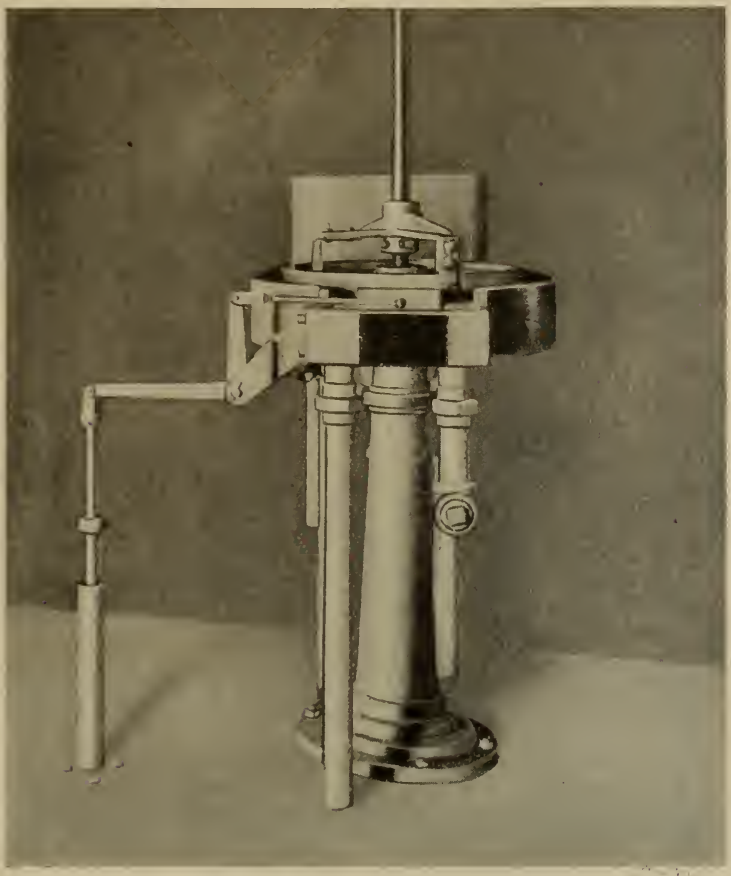


FIG. 9. CHEMICAL REGULATOR

Figure 10 is view of the softening tank room looking toward the weir box. The shafting and gears for operating the softening tank agitators are located in this room.

The precipitate which settles out of the water in the settling basins is removed by means of quick opening sludge valves located in the sludge disposal chamber.

There are six of these valves (Fig. 2), three serving each tank. The sludge removal system for each tank consists of three sections which

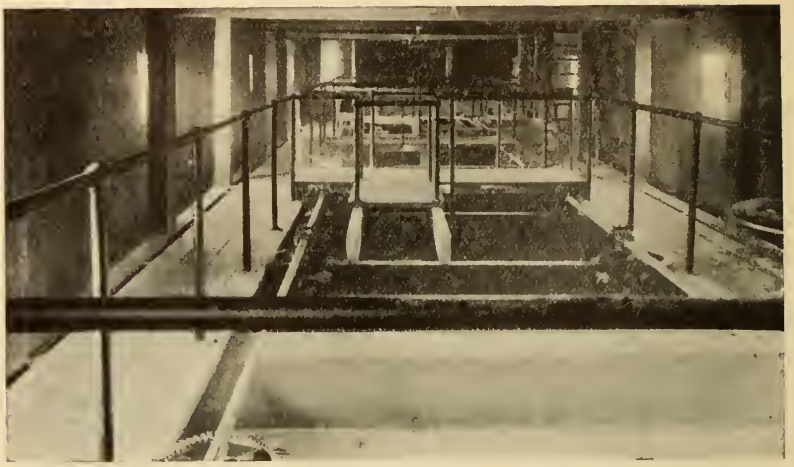


FIG. 10. SOFTENING TANK ROOM

serve the near, middle, and farthest portions of the settling basin respectively. The valve controlling that section which is nearest to the downtakes is, in actual practice, open for twenty seconds at a time. The valve controlling the middle section is open for ten seconds, and that controlling the farthest section, five seconds. It is the practice to operate each set of sludge valves four times daily.

Mineral analyses, such as those quoted above, are made only occasionally. It is the practice, however, to take three tests daily of the purified water. These tests serve as a check on the attendants who prepare the charge of chemicals. The tests made include hardness to

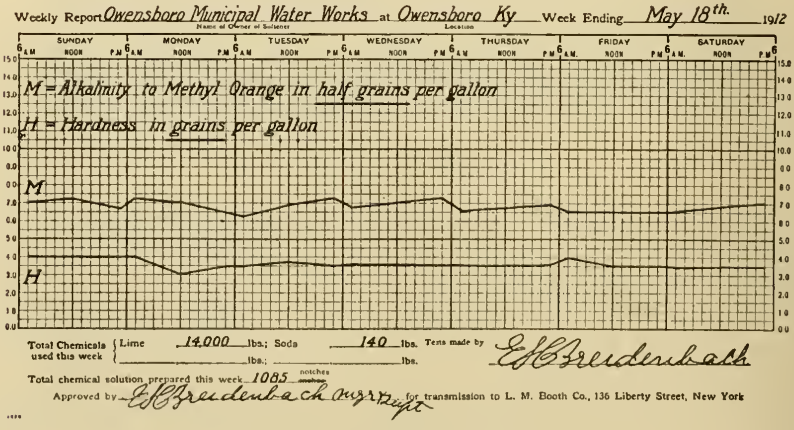

Weekly Report Owensboro Municipal Water Works at Owensboro Ky Week Ending May 18th. 1912
SUNDAY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
M = Alkalinity to Methyl Orange in half grains per gallon
H = Hardness in grains per gallon
M
H
Total Chemicals used this week Lime 14,000 lbs.; Soda 140 lbs. Tests made by E. H. Breidenbach
Total chemical solution prepared this week 1085 notches
Approved by E. H. Breidenbach
by transmission to L. M. Booth Co., 136 Liberty Street, New York

FIG. 11. WEEKLY REPORT CHART

soap, and alkalinity to both phenolphthalein and methyl orange. The results of a week's operation, which are typical of those ordinarily obtained, are set forth on the accompanying chart (Fig. 11).

While the softening plant was installed primarily to remove the objectionable mineral matter, it is also very efficient in removing bacteria from the water, as will be noted from the tabulation of a report from Dr. E. H. Mark, Kentucky state sanitary engineer, under date of May 15, 1912.

Tabulation of report by E. H. Mark, Kentucky state sanitary engineer to Owensboro Municipal Water Works, Owensboro, Ky., May 15, 1912.—1 cc. water tested from each source.

	OWENSBORO WATER WORKS COMPANY; OHIO RIVER FILTERED THROUGH SAND BED IN RIVER		OWENSBORO MUNICIPAL WATER WORKS RAW WELL WATER		OWENSBORO MUNICIPAL WATER WORKS SOFTENED WELL WATER	
	After 24 hours	After 72 hours	After 24 hours	After 72 hours	After 24 hours	After 72 hours
Gelatin.....	Too many to count	Completely liquefied	Too many to count	Liquefied	None	5 colonies[1]
Lactose bile	No gas	10 per cent gas	No gas	No gas	No gas	No gas

[1] This count is after 93 hours.

Dr. Mark closes his report with the following statement:

This would indicate that your filter is doing very good work, but that your untreated water wants to be carefully purified, and the water from the old plant is in bad condition.

As originally built, the top of the settling basin walls projected only a few inches above the surrounding earth embankment. A concrete guard wall around the three unprotected sides of each of the settling basins has recently been built. This wall will serve to keep out wind blown leaves, etc., as well as to afford protection to passersby. While the guard walls were building, one settling basin was used at a time, the other basin being out of commission to facilitate the concreting. During this period, an average of 2,100,000 gallons daily was settled in a single basin. According to our interpretation of results, there has been no appreciable change in efficiency as measured by hardness and alkalinity, due to cutting in half the time during which the water is in the settling basins. We conclude therefore that with a water which has been properly softened and coagulated, a long time of storage in the settling basin is not important.

While all of the water was being cared for in one of the settling basins, the one around which the wall was being built was emptied,

and we took occasion to observe the condition of the sludge removal system. The inspection served to confirm our opinion that the system in use is very efficient in carrying off the precipitate. Although more than four tons of sludge is produced daily, the average depth of sludge was found to be but eight inches; the maximum depth of sludge between the outlet orifices of the removal system was twelve inches. We estimate the amount of water required to draw off the sludge to be about $1\frac{1}{2}$ per cent of the total amount of water purified.

In the operation of the Owensboro water softening plant, it is our aim to purify the water so that it will be suitable for boiler feed and industrial uses, as well as for domestic consumption. The condition of the boilers at the municipal electric plant and at the water plant (2400 total horse power) is better than it has ever been since the boilers were new. After approximately six months use of softened water, we find that almost all of the old scale has cracked off, and that no new scale has formed in our boilers. We have no data as to saving in coal, but as the firemen's work is noticeably easier, we must be making a considerable saving in fuel.

The two ice manufacturing plants at Owensboro have adopted our softened water, with the result that their product is much purer and the ice is much more attractive looking than that formerly made when their boilers were fed with unsoftened water.

One expense item of considerable moment, which the introduction of softened water is saving the water department, is that for renewals of waterbacks in stoves. It was our practice to renew these when necessary without expense to our customers. The cost of this work amounted to about $1800 annually.

The total cost of the softening plant was $28,380.31. Following is a tabulated summary of the operation by months since the plant was first put into use. The writer will not read all of the details, but the itemized costs for chemicals, labor and electricity show that in softening 241,839,400 gallons of water, our average cost is $6.58 per 1,000,000 gallons.

This much has been said in order that you may know how the water supply for the people of Owensboro has been made purer, better and more useful. From a humanitarian standpoint, quite as much as commercially, the wonder is that it was not done years ago. For it cannot be said that the purification and softening of water is an entirely new and lately discovered process. The writer finds upon investigation that as early as 1841, water, by the application of lime, was softened and purified on a fairly large scale by Dr. Thomas Clark, of Aberdeen, Scotland. Throughout the hard water sections in

Tabulated summary of the operation by months since the plant was first put in use

MONTH	HOURS PUMPING	GALLONS OF WATER PUMPED	KILOWATTS CONSUMED	COST OF CURRENT	LIME USED	COST OF LIME	SODA USED	COST OF SODA	COST OF LABOR	TOTAL COST	H.	P.	M.	NUMBER OF TESTS	AVERAGE COST PER 1000 GALLONS
December 11 days...	167	15,030,000	541	$23.00	27,800	$62.50	539	$5.39	$20.88	$111 77	High 7.6 Low 3.2 Aver. 4.3	High 9.4 Low 1.5 Aver. 6.46	High 14.8 Low 7.0 Aver. 9.73	21	$\frac{\$0.74\frac{1}{2}}{100}$ of 1 cent
January.....	578	49,715,000	1788	71.52	90,000	202.50	none	none	72.25	346.27	High 6.8 Low 2.8 Aver. 4.1	High 11.7 Low 2.7 Aver. 6.17	High 13.3 Low 6.2 Aver. 8.16	86	$\frac{0.69\frac{3}{4}}{100}$ of 1 cent
February.. ..	571	49,335,000	1775	71.00	74,464	165.54	60	.60	71.37	308.51	High 4.5 Low 2.8 Aver. 3.5	High 6.3 Low 2.8 Aver. 4.67	High 8.3 Low 4.3 Aver. 6.72	85	$\frac{0.62\frac{1}{2}}{100}$ of 1 cent
March.....	461	40,699,350	1464	58.56	66,000	148.50	660	6.60	57.62	271.28	High 4.5 Low 3.0 Aver. 3.54	High 7.6 Low 3.8 Aver. 4.57	High 8.6 Low 5.5 Aver. 6.66	75	$\frac{0.66\frac{2}{3}}{100}$ of 1 cent
April.....	428	39,991,350	1438	57.52	62,000	139.50	620	6.20	53.50	256.72	High 4.5 Low 3.0 Aver. 3.5	High 7.8 Low 4.2 Aver. 5.07	High 9.0 Low 6.0 Aver. 6.9	73	$\frac{0.64\frac{1}{2}}{100}$ of 1 cent
May.....	503	47,068,700	1690	70.71	70,000	157.50	700	7.00	62.87	298.08	High 4.0 Low 3.0 Aver. 3.49	High 8.0 Low 4.0 Aver. 5.02	High 9.0 Low 5.0 Aver. 6.89	93	$\frac{0.63\frac{1}{3}}{100}$ of 1 cent
	2708	241,839,400	8696	$352.31	390,264	$876.04	2579	$25.79	$338.49	$1592.63				433	$\frac{\$0\ 65\frac{4}{5}}{100}$ of 1 cent

Europe, water softening has been practiced quite extensively. In America, in addition to numerous industrial and railroad softeners, the following cities, among others, have installed water softening plants: Winnipeg, Canada; Oberlin and Columbus, Ohio; New Orleans; McKeesport, Pa., Georgetown, Ky. Of these, the largest is at New Orleans, where a plant of 40,000,000 gallons daily capacity is in use.

The purpose of the municipal plant at Owensboro, as it should be of all other plants furnishing water, is, first, to furnish a water free from bacteria, and disease-producing bacilli, and the law of the state should compel this; second, to furnish a clear and soft water, free from odor and color for domestic purposes, and the people should not be satisfied with anything less.

The credit for the building of the Owensboro Municipal Water Works is due to a number of farseeing and determined business men living there, who, really and truthfully, took the welfare of the city and its people to heart, and would not rest until they saw the city owning and operating its own water works. Being wise men, they did not stop at the building of the plant, but they placed the operation and management of it in the hands of a commission, a non partisan board of three men who serve without pay. These commissioners are selected by the council and the term of office is three years, one commissioner being elected each year.

The writer commends the plan; for it has been his observation that in so far as politics is permitted to have anything to do with the utilities of a city, they have been not only inefficiently and poorly operated and managed, but in many instances have been failures.

If the plant at Owensboro shall continue under the management of the commission composed of such men as those who have had charge of it since 1906, the writer predicts that it will ever remain a monument to the patriotism and public spirit of those men who thought and lived and labored not for themselves, but for others.

DISCUSSION

A MEMBER: How many degrees of hardness and alkalinity in the raw water there?

MR. E. H. BREIDENBACH: This water shows 14 but we treat it and the average according to this total shows practically about $3\frac{1}{2}$ hardness. Our rain water when we catch it there tests out 4. The table given in the paper gives the figures.

CHLORINATION AT CLEVELAND, OHIO

By D. D. Jackson

When the chlorinating plant for treating the water supply of Cleveland was placed in operation in September, 1911, disagreeable tastes and odors were noticed from time to time and investigations were undertaken to regulate the application of the chemical and determine its effectiveness as a sterlizing agent. It was found that the unsatisfactory results were due to the use of unnecessarily large amounts of chlorine. The quantities of chlorine have been reduced while the sterlizing effect upon the water has been sufficiently active. The efficiency of the process was demonstrated during the present year, both by analytical results and by the fact that ice movements in April caused specific infection in the water supply at the intake during three days, yet there was no accompanying rise of typhoid in the city.

Since the installation of the new 4 mile intake the water supply of Cleveland has been in a satisfactory sanitary condition at all periods of the year, with the exception of the short intervals during which the annual breaking up of the ice has occurred. The sewage laden ice from the river and harbor has, on several occasions, infected the supply at that time, especially in 1910 when the ice movements were oscillating and protracted.

Under present conditions infection occurs only during and directly after the ice movements and it is at these times only that it is imperative to treat the water with hypochlorite. In order to insure the use of standard amounts of chlorine when sudden increase or decrease in pumping takes place, it has been recommended that an automatic device be installed which will regulate the flow of hypochlorite solution directly in proportion to the flow of water, and that experiments be made with a view of substituting for the chemical solution, compressed chlorine gas made directly from the electrolysis of common salt. This gas is more effective at low temperatures, is readily eliminated from the water by its more rapid reaction, can be easily regulated and is in all respects like treatment with ozone, but more practical of application and much less expensive. The estimated cost of an installation for Cleveland is $2000 and the cost of treat-

ment from 40 cents per 1,000,000 gallons downward to about 25 cents, as liquid chlorine comes into general use and is made on a larger scale.

With the present funds available for water works purposes at Cleveland it is proposed to extend the old intake line to a point 16,000 feet northwesterly from the old west side crib, thereby having two long lines ready for use so that in case of accident in one of the tunnel lines, the other would be available for use while repairs were in progress on the damaged line. The extension of the old intake together with the installation of permanent sterilizing apparatus to treat the lake water is believed to be a satisfactory method of insuring a pure supply of water.

The present chlorinating plant consists of a small mixing tank four feet in diameter and three feet four inches deep, equipped with a mechanical stirrer. There are two 11 foot 8 inch diameter solution tanks, 7 feet 5 inches deep. A one per cent mixture is used, the feed being controlled by two orifice tanks with float valves. The daily pumpage is about 70,000,000 gallons and from 11 to 16 pounds of hypochlorite per 1,000,000 gallons are used, corresponding to an amount of chlorine of from 0.5 to 0.7 parts per million. Sudden changes in pumpage together with the sometimes great variation in the strength of the individual drums of chloride of lime has, at times, been the source of difficulty in the application of the treatment. This difficulty was greatest at the time when it was thought that 0.8 parts per million of chlorine was necessary; it is now found that 0.5 parts is sufficient. Any amount in excess of 0.8 parts produces, during cold weather, objectionable tastes and odors.

In Jersey City, where the first practical tests of the treatment were made, it was found that 0.35 parts of chlorine per million was sufficient; this amount has been used also at Cincinnati and in other cities. In the Croton supply of New York 0.5 parts was required and in the Bronx supply 0.6 parts.

Compressed chlorine, liquefied under pressure, is now on the market sold in 100 pound cylinders and can be had at about 8 cents per pound, which is about double the price of hypochlorite of lime, as far as available chlorine is concerned. It has, however, many decided advantages over the hypochlorite in that it is a pure and definite product which is absorbed by the water as a gas. It is easier to apply with regularity and its added cost is nullified by the fact that almost no labor is required in its application. No solution tanks are necessary and no lime sludge has to be disposed of. The only installation required for this treatment is a gas pressure regulator, with pressure

TABLE 80

Effect of temperature on chlorination of Cleveland water—Hypochlorite of lime used

		68° F.	34° F.
B. typhi, control		10,000	10,000
0.6 parts per million chlorine, in	15 minutes	5	1,000
	1 hour	0	100
	72 hours	0	1
B. paratyphi B. control		100,000	100,000
0.6 parts per million chlorine in	15 minutes	10	10,000
	30 minutes	1	10
	72 hours	0	0
B. paratyphi B. control		1,000,000	1,000,000
0.7 parts per million chlorine, in	15 minutes	100	10,000
	30 minutes	1	10
	72 hours	0	0
B. coli control		100,000	100,000
0.6 parts per million chlorine in	15 minutes	0	1,000
	1 hour	0	100
	72 hours	0	0
B. coli control		100,000	100,000
1 part per million chlorine, in	15 minutes	0	100
	1 hour	0	1
	72 hours	0	0

TABLE 81

Special chlorination experiments—Using liquid chlorine or compressed chlorine gas

		33.5° F.
B. paratyphi B. control in distilled water		1,000,000
0.6 parts per million chlorine in	15 minutes	1
	30 minutes	0
	72 hours	0

		68° F.
B. paratyphi B. control in Cleveland water		1,000,000
0.6 parts per million liquid chlorine in	15 minutes	100
	30 minutes	10
	5 hours	0

		36° F.
B. coli control in Cleveland water		100,000,000
0.6 parts per million liquid chlorine in	15 minutes	1,000
	30 minutes	1
	5 hours	0

		36° F.
Cleveland water with usual bacterial content		250
0.5 parts per million liquid chlorine in	15 minutes	22
	30 minutes	20
	5 hours	19

gauges on either side of the regulator. The gas then passes to a series of hard rubber orifices and is absorbed in the flowing water. The only labor required is about five minutes work to connect up a new 100-pound tank once in six hours, in the case of the Cleveland supply.

In regard to typhoid fever, since the new 4-mile intake was installed in 1904, the death rates have been low. During the year immediately following the installation of the new intake the typhoid death rate dropped from 48 to 15 per 100,000 and has averaged 16 for the seven years that this intake has been in use. In spite of the low death rate there have been occasional times when for short periods the water appeared to be the source of slight infection and this infection occurred always in the early part of the year. It was to stamp out this source of risk that the sterilization of the supply was adopted.

In connection with a study of the typhoid situation in Cleveland a chart was prepared showing the monthly typhoid fever death rates of various typical groups of cities with respect to the seasonal distribution of the disease. This seasonal distribution is of necessity a factor in the determination of the mode of transmission of typhoid fever and has a marked bearing on studies of fly infection. It will be seen in this diagram that in those cities, such as Munich, Dresden and Hamburg, where the water and sewage conditions are properly controlled and where general sanitation is excellent, that the distribution of the disease by months is practically uniform and low throughout the year.

In the second portion of the diagram is shown the seasonal distribution of typhoid fever for New York and Boston for a period of ten previous years as compared with that of 1911. It is noted that the high summer and fall rise of typhoid fever in both of these cities as indicated by former years has been enormously reduced, until in the year 1911, the results have fallen to a point approaching those of the German cities above indicated. This great reduction has not been brought about, in the case of New York and Boston, by any material changes in water supply, but by improvements in general sanitation, which have a bearing on fly transmission.

In the third portion of the diagram is shown the typical seasonal distribution of cities which formerly had infected water supplies and which have greatly improved those supplies. A comparison of the months previous to and after improvement shows a change from the high typhoid fever rate throughout the year to a rate which approaches nearly ideal conditions; with the practical removal of

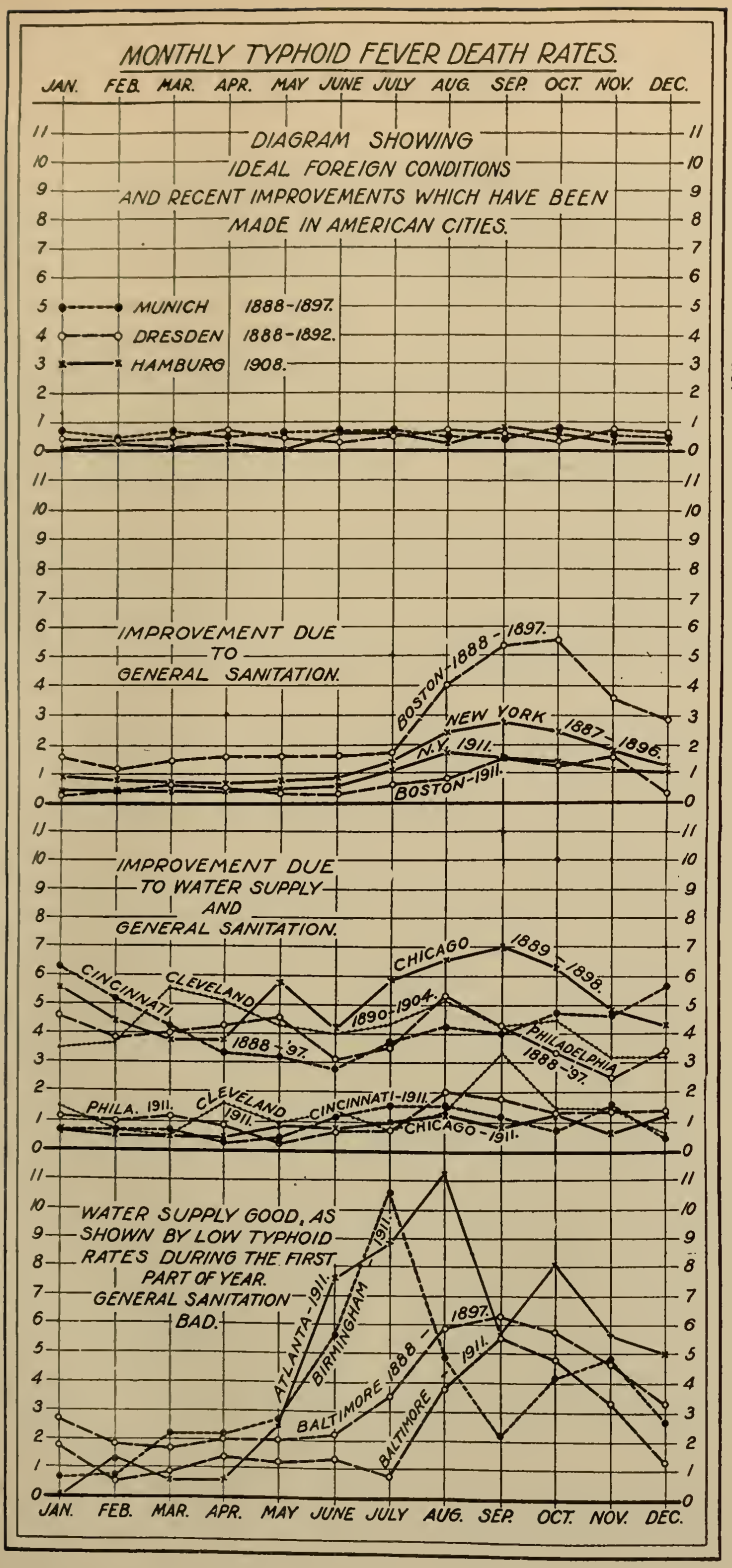

MONTHLY TYPHOID FEVER DEATH RATES.
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEP. OCT. NOV. DEC.
DIAGRAM SHOWING
IDEAL FOREIGN CONDITIONS
AND RECENT IMPROVEMENTS WHICH HAVE BEEN
MADE IN AMERICAN CITIES.
MUNICH 1888-1897.
DRESDEN 1888-1892.
HAMBURG 1908.
IMPROVEMENT DUE TO GENERAL SANITATION.
BOSTON-1888-1897.
NEW YORK 1887-1896.
N.Y. 1911.
BOSTON-1911.
IMPROVEMENT DUE TO WATER SUPPLY AND GENERAL SANITATION.
CHICAGO 1889-1898
CINCINNATI
CLEVELAND
1890-1904.
1888-97.
PHILADELPHIA 1888-97.
PHILA. 1911.
CLEVELAND 1911.
CINCINNATI-1911.
CHICAGO-1911.
WATER SUPPLY GOOD, AS SHOWN BY LOW TYPHOID RATES DURING THE FIRST PART OF YEAR. GENERAL SANITATION BAD.
ATLANTA-1911.
BIRMINGHAM 1911.
BALTIMORE 1888-1897.
BALTIMORE 1911.
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEP. OCT. NOV. DEC.

DIAGRAM No. 3.

typhoid in excess of normal at any season of the year except in the summer and fall and a great reduction during that period.

In a number of cities studied where the typhoid rate was uniformly high throughout the year, due to water infection, filter plants have been installed or other important improvements in water supply made, and it is observed that the chart of seasonal distribution of typhoid thus changes its character, becoming low throughout the year, except in the spring and fall where moderate or high rises take place, depending upon the prevailing general sanitary conditions. This is a strong indication that this fall rise is not due to water supply, but that general sanitation and fly infection have a direct bearing upon it.

In the fourth portion of the diagram is shown two cities (Atlanta and Birmingham), both with filter plants and both with low typhoid rates during the winter period, but with extremely high typhoid rates during the summer and fall. Unsanitary conditions undoubtedly account for this summer fall and rise.

HYPOCHLORITE STERILIZATION AT KANSAS CITY, MISSOURI

By S. Y. High

The water supply of Kansas City, Mo., is taken from the Missouri River about five miles above Kansas City, at the Quindaro Station in Kansas. The water is pumped directly from the river into settling basins. The water is then treated with lime and sulphate of alumina. After leaving the basins through the back flow or suction pipe, the hypochlorite solution is introduced, before the water gets to the pump, the pump agitation making a thorough mixture of the hypochlorite with the water.

From the Quindaro Station the water is pumped to the Turkey Creek Station 12,000,000-gallon reservoir, and from this reservoir to the service mains.

Since the demonstration at Boonton, N. J., in 1909, of the reduction of bacteria by the introduction of minute quantities of "available chlorine" with water more or less polluted, and the acceptance of the process by the courts as a proper method to be employed in connection with a municipal water supply, the question of the efficient introduction of hypochlorite of lime solution and the mechanical appliances suitable for the purpose, engaged the attention of the fire and water commissioners of this city. They ordered the city chemist, Dr. W. N. Cross, to make a trip of inspection of several cities known to have the hypochlorite sterilization system in satisfactory operation.

Dr. Cross found the method of installation of the system both easy, cheap and satisfactory. The fire and water commissioners immediately took steps to install this system of treatment for its entire municipal water supply of Kansas City.

During the year 1911 an experimental installation of the hypochlorite process for the approximate sterilization of the entire municipal water supply of Kansas City was so successful that the Kansas City fire and water commissioners undertook the construction of a permanent building and apparatus for the application of this purification process to the water supply.

A separate building was constructed to make possible the satisfactory storage, handling and making of the solution of hypochlorite ready for mixing with the sedimented water.

The building itself was designed by W. C. Root, an architect, and the apparatus for use in connection with the sterilization process was installed under the direction and supervision of Burton Lowther, engineer in charge.

The apparatus for the handling of the hypochlorite and the supports for it are of reinforced concrete. It is to be observed that no other material is so well suited for use in connection with this sterilizing agent as good concrete, for the reason that all other materials that are capable of oxidation are promptly attacked by the hypochlorite solution and become rapidly deteriorated. The prime consideration with regard to this class of installation is to employ such methods of construction and to use material that is so permanent in character as to obviate the necessity of repairs which would force the discontinuance of the application of the sterilizing agent even for an hour.

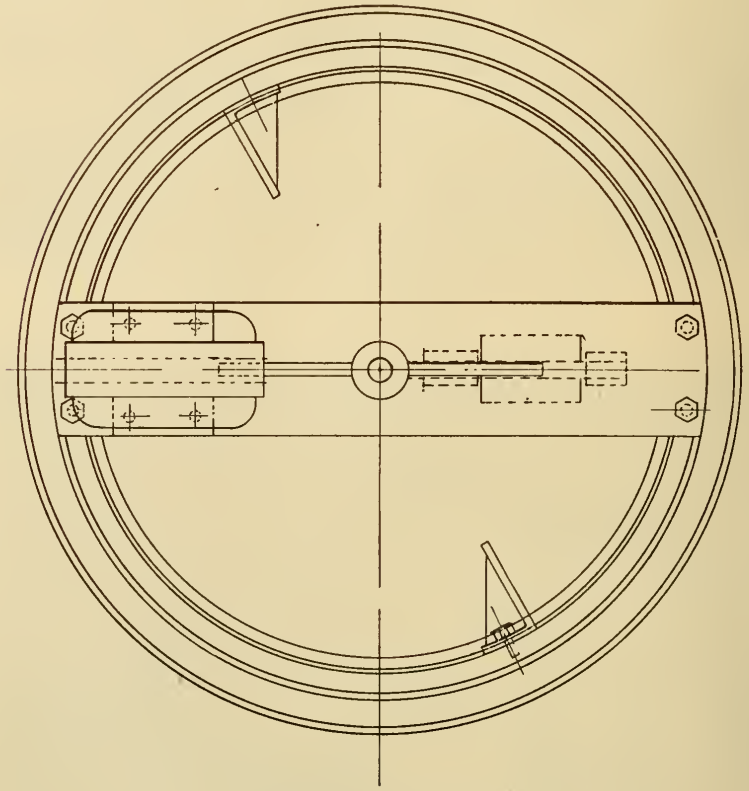
The basement of the building is used for storage of the reagent that is kept in reserve. The main floor is used to house the dilution tanks and the feeding devices, while on the floor above is placed the tank in which the hypochlorite is reduced to paste of a creamy consistency before being delivered to the dilution tanks beneath. This pasting tank, 3 feet in diameter and 4 feet high, is provided with a stirring device carrying two rather heavy rollers disposed horizontally at its lower end.

The rollers clear the bottom of the concrete tank only by a fraction of an inch, thus insuring the mashing and disintegration of all of the small lumps that are invariably present in commercial calcium hypochlorite. Owing to the fact that the action of the reagent on bronze is to form on the surface of it a fairly insoluble and protective coating of metallic carbonate and oxychloride, that metal appears to be the most available for use on all bearings and stirring or disintegrating devices that come in contact with the solution. Leading from the concrete pasting tank are pipes so arranged that the contents of the tank may be discharged into either of the large dilution tanks on the floor beneath. The outlet of the pasting tank is placed at a considerable distance from its bottom so as to avoid the possibility of drawing off with the paste any fragments of considerable size. The pipes carrying the paste are so arranged as to be readily cleaned in a few minutes in the event that they become clogged. Ultimately they are sure to become clogged if they are not occasionally cleared because of the formation in them of carbonate from carbon dioxide absorbed from the air.

EXPERIMENTAL HYPOCHLORITE BUILDING

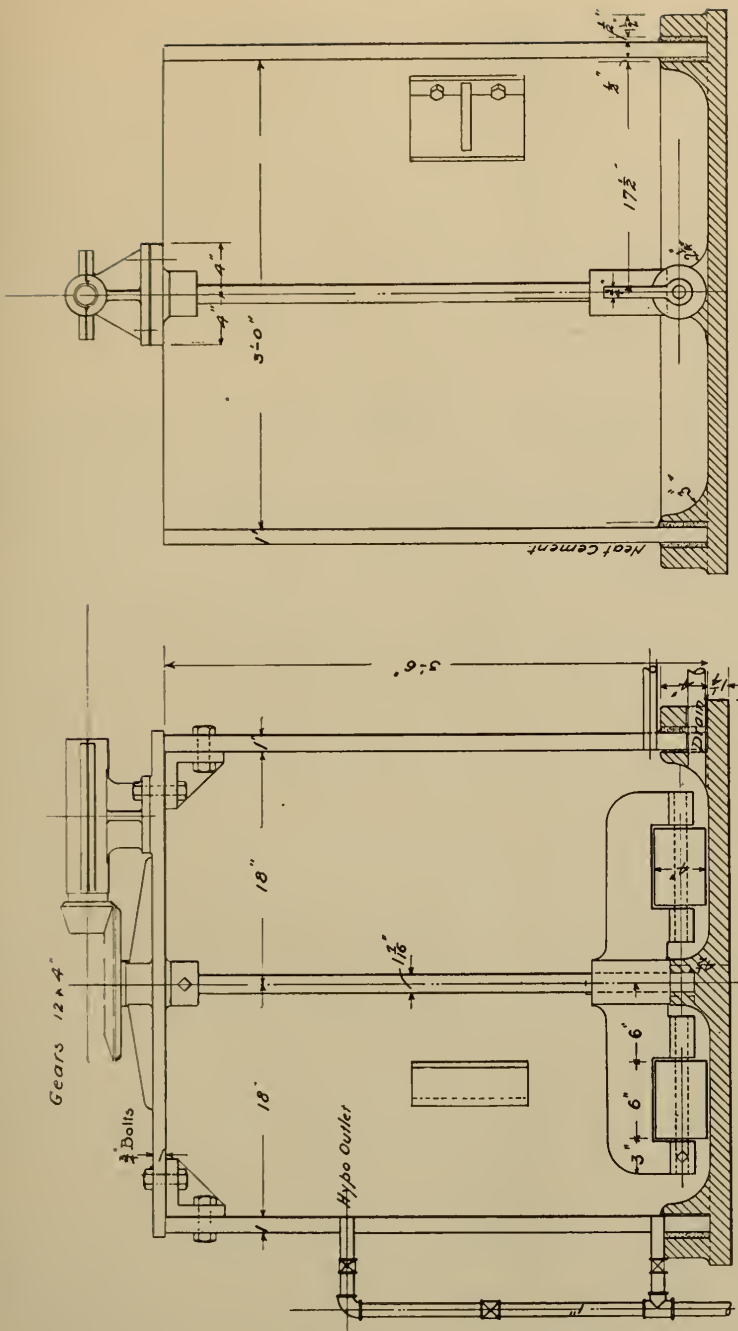
PERMANENT HYPOCHLORITE BUILDING

The dilution tanks are octagonal in form, 9 feet in maximum diameter and 7 feet high. Their walls are 6 inches thick. Although the difficulty experienced in properly disposing the reinforcing iron in the construction of a octagonal tank is much greater than is the case in the building of a round one, the octagonal tank is to be preferred on account of the fact that in a round tank a rotary stirrer does not produce nearly such thorough agitation and mixing of the



Pasting Tank—Section

solution of hypochlorite as the same stirrer can do in the octagonal tank. The paste is mixed with water in the dilution tanks until a uniform solution of a strength of 2 per cent occurs. The use of the two tanks makes it possible to accurately adjust the strength of the solution in one dilution tank while the contents of the other is being utilized. The dilution tanks are placed on supports high enough to



PASTING TANK—SECTION

permit the use of a gravity feed to the orifice box, which is placed on the floor of the room housing the big tanks.

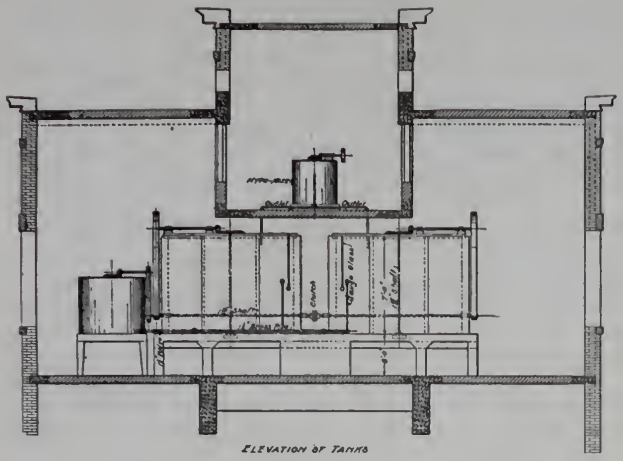
Bronze pipes, $1\frac{1}{2}$ inches in size, so arranged to be readily cleaned in the event of stoppage, connect the dilution tanks with a gauging tank 4 feet in diameter. This gauging tank contains a float, scale and pointer so arranged that the man in charge can accurately check the speed of outflow of solution from his orifice box into the big water main carrying the entire city water supply from the settling basins to the pumps. The solution passes through the gauging tank to the orifice box. Each division on the gauge represents 1 gallon of the hypochlorite solution.

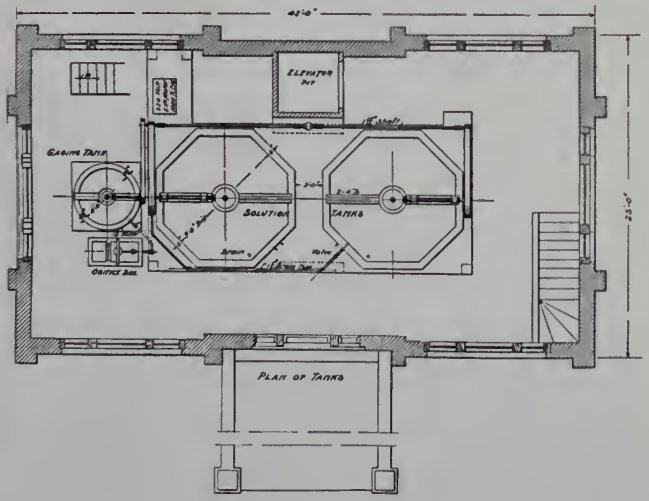
The orifice box is oblong in shape and carries a float of about 250 cubic inches displacement. The float operates a valve which, by either opening slightly or closing, maintains the hypochlorite solution in the orifice box to a constant level. One end of the orifice box is of plate glass to enable the operator to see at a glance that the solution is filling the box to the proper height. Attached to the plate glass and covering a hole in it, is a hard rubber disc having near its periphery several slits the adjustment of which represents the size of a stream of the 2 per cent hypochlorite solution that will be the proper amount to treat the quantity of water passing through the main. All movements of the hypochlorite solution after its preparation are by gravity. Ample opportunity for the hypochlorite after its addition to the water to react with any putrescible organic matter and germs, is afforded during the time in which the water passes through the centrifugal pump, the flow line and a small storage basin at Turkey Creek before it is pumped to the domestic water users.

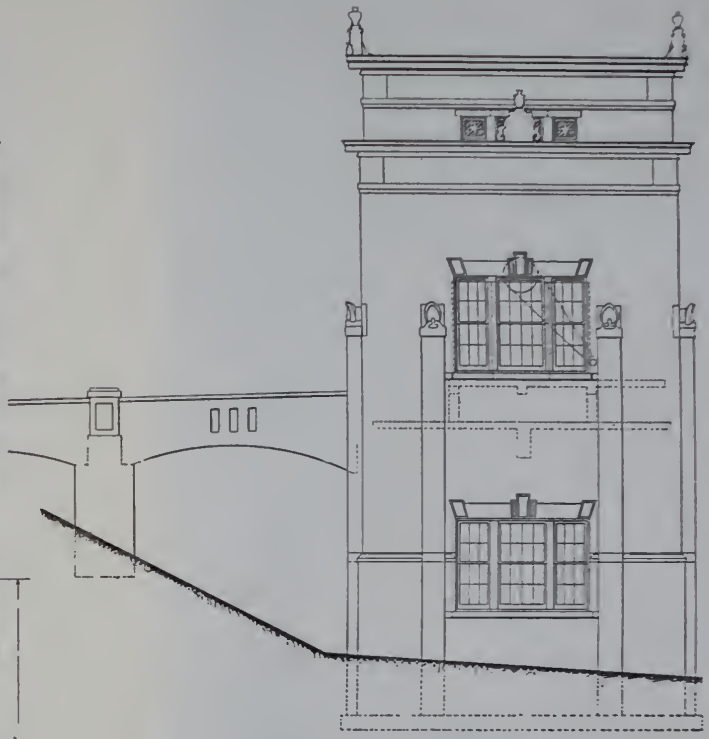
All of the stirring devices are run by an electric motor belted to a line shaft carrying clutches so placed as to make possible the running of any one of the stirrers whether or not any of the others are running.

The principle involved in the construction of practically all hypochlorite installations for the purification of water by the oxidation of germs and putrescible organic matter in municipal water supplies, is substantially the same as that in Kansas City. Concrete, usually reinforced, is, so far as the writer knows, universally used in the construction of all permanent apparatus for the preparation and solution of the hypochlorite for mixing with the water to be purified.

We find 0.30 to 0.50 parts per 1,000,000 available chlorine necessary to sterilize, or about 0.5 part per 1,000,000, or from 8 to $12\frac{1}{2}$ pounds hypochlorite per 1,000,000 gallons. This amount removes, under ordinary conditions, all B. coli and 99 per cent of all germs,







Hypochlorite Plant
Kansas City Mo. Water Works

SCALE 1/16"

The cost is about 30 cents per 1,000,000 gallons for labor and material, not including interest and depreciation on plant. As the plant is not yet completed we are unable to arrive at this additional cost. This additional cost will be small. The 30 cents cost for sterilization is based on a 30,000,000 gallon consumption. When the consumption increases the cost is less than 30 cents per 1,000,000 gallons, so that it probably will not exceed that amount including interest and depreciation, as the pumpage during the hot and cold months averages over 40,000,000 gallons.

In view of the fact that a great many cases of typhoid fever are imported and that there are still open and being constantly used numerous springs, wells and cisterns, known to be contaminated with sewage, the result has been all that could have been anticipated. During the year 1910 no specific attempt was made to destroy pathogenic germs in the municipal water supply. During the year 1911 the hypochlorite process was used throughout the year.

The following tabulation showing the number of deaths from typhoid fever month by month during those years is illuminating:

Deaths

MONTH	1910	1911
January	17	6
February	21	6
March	10	4
April	8	3
May	3	4
June	7	1
July	9	5
August	8	6
September	6	3
October	6	8
November	4	6
December	8	9
Totals	107	61

Now, with this great source of danger from infection by the municipal water supply removed, it is possible for the health commissioner to so enforce the abandonment of questionable sources of water supply and regulate sanitary conditions as to make the occurrence of typhoid fever and most intestinal diseases an uncommon thing in Kansas City.

The following are some germ counts on the city water supply showing the improvement of the water by the hypochlorite process:

Germs in 1 c.c. of water

DATE	QUINDARO RIVER BEFORE TREATMENT	CLEAR BASIN BEFORE TREATMENT	HYDRANT AT CITY HALL AFTER TREATMENT	B. COLI AFTER TREATMENT
March 20	10,000	1,200	75	0
March 21	8,000	1,800	70	0
March 23	4,000	800	100	0
March 24	10,000	500	55	0
March 25	8,000	600	90	0
March 27	8,000	400	25	0
March 28	5,000	260	20	0

DISCUSSION

President Gwinn: We are using hypochlorite, and know something about the wonderful results that are obtained. We also have heard of some places where it has not been satisfactory. Perhaps the difference is in the application or because of the conditions under which it has been used. We will be very glad to hear from gentlemen who have had experience in this line. We want to hear from everybody who has something to offer on this subject.

Mr. J. S. Butler: The speaker would like to ask for some practical information. Our water supply is perfectly pure, but we are anxious to keep it so. We have had recently a break in the main which allowed some polluted water to enter, and the main has become filled with polluted water. How to clean that main absolutely and reliably is a question he would like to have answered in connection with this paper.

Mr. George G. Kennedy: On several occasions the speaker has been called on to treat water in the vicinity of Harrisburg that was polluted in just the same manner to which the gentleman refers. The usual supply was received from the filter plant of the city across the river, the water being conveyed through a temporary pipe laid on the bed of the stream. This supply was furnished during the time the company was building a filter to treat their regular supply. When the ice went out, the pipe, of course, was damaged and the only safe resource was to pump raw river water, properly treated. This was done for several days without any treatment, when a vigilant inspector of the state board of health appeared on the scene and trouble began.

The published results of two treatments made in 1910 in our department show that the application of 0.08 of a grain of hypochlorite reduced the bacteria in the treated water over 99 per cent. The Coli, from being practically constant in the raw water, were present in but 4 per cent of the samples of treated water.

Similar results were received at a temporary plant using a supply from a creek and an obsolete filter, using the average dose of 0.075 grain per gallon. These were early cases in the use of hypochlorite.

The results of treatment of the latest case, as taken, show that when the contaminated water was all out of the reservoir, the bacteria in the raw water was reduced 95 per cent and made safe by the removal of almost all the B. Coli, which showed its presence in but one-half of 1 per cent of the 170 1 cc. samples taken. From $7\frac{1}{2}$ to 9 pounds of bleach was used per 1,000,000 gallons.

The results of this method have been very successful in these cases of emergency.

Gettysburg, Pa., treatment with hypochlorite of lime

DATE 1910	BACTERIA PER CUBIC CENTIMETER			B. COLI.			LITTLE MARSH CREEK		BIG MARSH CREEK		AVAILABLE CHLORINE
	Raw	Treated	Res.	R.	T.	Res.	Bact.	B. Coli.	Bact.	B. Coli.	Per cent
August 8	1820	32		5/5	0/5						
10	1900	24		5/5	0/5						33.00
12	1240	60	250	5/5	2/5	5/5					28.00
15	1160	48	51	5/5	1/5	0/5					15.80
17	1480	35	118	5/5	0/5	0/5	1360	5/5	1800	5/5	27.58
19	1400	58	56	5/5	0/5	0/5					36.10
21	1450	47	65	5/5	0/5	0/5					29.37
24	975	40	68	5/5	0/5	0/5	Treated and Filtered				26.90
27	550	42	52	5/5	1/5	0/5	60	0/5			32.31
31	840	56	42	5/5	0/5	0/5	63	0/5			28.37
Sept. 3	920	72	185	5/5	0/5	5/5					29.46
7	1120	56	72	5/5	0/5	0/5					33.10
10	750	42	45	5/5	0/5	0/5	No. 1		No. 2		41.76
15	600	21	25	3/3	0/3	0/3	1040	3/3	280	3/3	26.79
17	760	29	36	5/5	0/5	0/5					21.50
24	5740	75	52	5/5	0/5	0/5					31.52
29	1990	28	73	3/3	0/3	0/3					17.50
Average	1453	45	79	81/81	4/81	10/71			.		28.69

Dr. J. L. Leal: The sterilization of potable waters by the use of hypochlorite of lime as a continuous process of water purification was first put into operation for the Jersey City Water Supply Company, at Boonton, New Jersey, in connection with the supply of Jersey

City, on September 23, 1908, the reason for such step being the fact that the water supplied to Jersey City (about 40,000,000 to 43,000,000 gallons per day) was, in the opinion of the court, not sufficiently purified by the process of sedimentation and other natural agents acting in a reservoir with a capacity of 8,500,000,000 gallons, to conform with the contract between Jersey City and the company, which required at all times "a pure and wholesome water."

It was admitted by the company to be practically impossible to fulfill the contract by any attempt to keep out pollution, and the necessary loss of head made it impossible to filter such supply. The process of sterilization was therefore recommended by the speaker and adopted by the company. The necessary plant and apparatus was constructed according to plans furnished by the firm of Hering & Fuller of New York, Mr. George A. Johnson of said firm being placed in immediate charge of its operation, and continuing in charge until January 1, 1909, when it was taken over by the company. The process was successful from the beginning, and the operation resulted in the approval of the process by the Courts of Chancery and Errors and Appeals of the State of New Jersey; said courts deciding that by its use all the requirements of the contract with respect to the quality of the water were fulfilled.

Since the process was put into operation at Boonton, it has been employed in connection with many water supplies throughout this country, and in connection with water supplies in Holland, Belgium, France, Germany, Great Britain, South Africa and Asia. According to the best information obtainable by the speaker it is in practically continuous use today in connection with about 300 water supplies in this country, and has been used in emergencies, during outbreaks of epidemics, in connection with about 100 other supplies.

In some instances, it is used as the only process of purification; in others, it is used in connection with sedimentation or settling, and in still others in connection with filtration, either slow sand or rapid mechanical.

The results obtained have been both satisfactory and unsatisfactory. The unsatisfactory results have been due to improper construction of plants, inefficient or insufficient supervision, and unskilled operation. The process seems so simple that it has been in many instances installed, supervised and operated by those without proper knowledge, training and experience, with the results always to be looked for under such conditions. The truth is that although the process is a simple one, in order to obtain satisfactory results it is

necessary that plants should be installed and operated only by those possessing the necessary qualifications, namely, proper knowledge, training and experience. In such instances, the results must of necessity be satisfactory, as has been proven, not only theoretically, but by practical experience, in many cases.

In connection with unfiltered but sedimented waters, the process has been operated the longest, and with probably the most uniformly successful results, at Boonton, New Jersey, in connection with the Jersey city water supply. These results are as follows:

TABLE I

Average number of bacteria per cubic centimeter at Boonton, N. J.

MONTH	1908–1909		1909–1910		1910–1911		1911–1912	
	Raw water	Treated water	Raw water	Treated water	Raw water	Treated water	Raw water	Treated water
October	320	7	600	26	500	23	2100	125
November	196	7	1300	24	2200	120	2400	75
December	590	3	19500	130	1400	45	2100	46
January	850	13	3100	43	7500	60	1400	22
February	975	4	2100	49	3800	30	8500	12
March	1900	325	5800	58	4300	23	22000	60
April	1100	110	1300	25	2800	24	3500	28
May	750	13	1700	19	1200	9		
June	260	11	1700	10	1000	5		
July	210	7	200	14	850	9		
August	375	18	120	14	325	21		
September	450	21	250	70	750	23		
Average	665	45	3139	40	2219	33	6000[1]	53[1]

[1] Seven months.

In connection with filtration, the best results have been obtained at Little Falls, New Jersey, at the plant of the Associated Water Companies of Northern New Jersey, supplying Paterson, Passaic, Montclair, Little Falls, Nutley, West Orange, Glen Ridge, Bloomfield, Kearney, Harrison, East Newark and Bayonne; the average daily amount of water delivered being about 30,000,000 gallons; and at Cincinnati, Ohio.

The results obtained at Little Falls will be found in Table II.

In the opinion of the speaker we are justified in claiming, that the utility of this process of water purification has been established beyond dispute as an adjunct to sedimentation and filtration, either slow sand or rapid mechanical. It cheapens the installation of filtration by practically eliminating for the future all necessity for slow sand filtration; the desired results of such form of filtration being obtained

more cheaply, more rapidly, and on much less area, by rapid mechanical filtration and sedimentation. It is indeed in use today in connection with practically all the slow sand filtration plants in this country.

Its utility in connection with sedimented supplies has also been amply established by the results obtained at Boonton, Omaha, Kansas City and other places. It has proven applicable to any supply for the purpose of removing the dangers of infection. It will not remove turbidity or color, but where these two elements are negligible, it is applicable as a continuous process. It has proven applicable in

TABLE II

Yearly summary of results of operation of filtration works, Little Falls, N. J.

YEAR Fiscal year begins September 1	PER CENT OF WASH WATER	SULPHATE OF ALUMINA		PART PER MILLION				BACTERIA PER CUBIC CENTIMETER		
				Turbidity		Color				
		Pounds per day	Grains per Gallon	River	Filtered	River	Filtered	River	Filtered	Treated
1902–'03	3.5	2330	1.28	11	1	35	6	3500	70	
1903–'04	2.8	3060	1.26	18	0	34	6	2600	55	
1904–'05	2.6	4150	1.28	12	0	29	5	1500	50	
1905–'06	3.2	4720	1.49	8	0	32	4	2500	110	
1906–'07	3.8	4340	1.24	9	0	25	3	2000	65	
1907–'08	3.6	4940	1.41	9	0	31	3	1300	35	
1908–'09	3.5	4930	1.44	9	0	28	3	2900	48	
1909–'10	3.7	7740	2.03	10	0	40	5	5300	100	
Average	3.3	4526	1.43	11	0	32	4	2700	66	
September 1, 1910–'11	3.9	4530	1.12	11	0	45	8	4500	269	16[1]
September, 1911–May, 1912	2.6	4600	1.08	12	0	47	7	4156	218	3[2]
Average	3.2	4565	1.10	12	0	46	8	4328	244	9

Number of days from September 1, 1910, to September 1, 1911, when treated water was sterile.....21

Number of days from September 1, 1911, to May 1, 1912, when treated water was sterile.....47

[1] Hypochlorite applied before filtration.

[2] Hypochlorite applied after filtration.

connection with supplies of all characters during times of epidemics, as a temporary measure.

It seems justifiable to make the statement, based upon nearly four years' experience and upon the conclusions reached by many eminent water supply experts, that a sterilization plant is indicated in connection with every water supply, whether it be used as the only process of purification, or whether it be used as an adjunct to other processes. It is a safeguard under all conditions which is well worth the low cost of its installation and maintenance.

Its general use in the purification of potable waters will result in the saving of more lives and the economic losses resulting therefrom than any advancement made in sanitary science in years, with the single exception of the discovery of the immortal Reed and his associates.

One point upon which Doctor Jackson laid particular emphasis, the speaker would like to receive more light upon. Doctor Jackson said that 10 per cent only of typhoid cases could be attributed to the water supply in the majority of cities. Afterward he stated that practically 50 per cent were contact cases; so that, eliminating the contact cases we have 20 per cent remaining cases attributable to the water supply, and 80 per cent attributable to sanitation; yet on the diagram, some of the few cities he showed, namely, Cincinnati, Cleveland, Philadelphia and Chicago, the improvement in the water supply had reduced the typhoid cases 75 per cent. We all of us know of other cases in which the typhoid rate has been diminished anywhere from 75 to 80 per cent by the introduction of a pure water supply, and the speaker would like to know if Doctor Jackson could tell us how it is that only 20 per cent can be attributed to the water supply unless the reduction of 75 per cent is effected by purifying the water.

Mr. D. D. Jackson: Ten per cent the speaker would attribute to the water supply in the city of Cleveland. He does not apply any specific percentage to cities in general throughout the United States. We have now such a large number of cities that have filtration, and such great improvements in general sanitation, that the percentages which would be referable to general sanitation and to water supply have both been greatly reduced, and especially so in relation to the water supply. In those cities where the past year's rates are given there were perhaps two or three, or even more, where 75 per cent of the typhoid came from water, unquestionably; but speaking of our cities in general, especially our large cities, the great proportion of our typhoid at the present time is coming from general sanitation, particularly in the South.

Mr. A. Prescott Folwell: Do you mean that in the cities whose water supply has been improved to a very large extent you still find 10 per cent of typhoid due to the water and 90 per cent due to general sanitation?

Mr. D. D. Jackson: No. That applies specifically to Cleveland and since chlorination all typhoid from water has been eliminated. In these days many of our cities have practically no water-born typhoid. Throughout the United States the speaker thinks there is more typhoid from lack of general sanitation that from water supplies, but that does not apply specifically to any one city. In some cities most of the typhoid is from water, but there are many cities in which there is no typhoid from water at all. In these cases, most of their typhoid is from lack of general sanitation. At Atlanta, Georgia, and Birmingham, Alabama, they have a typhoid rate of about 50, mostly occurring during the fall rise, and both those cities have filtered water. Their typhoid rate of 50 per 100,000 is due the speaker might say almost entirely to lack of general sanitation.

Mr. George G. Kennedy: Speaking of typhoid fever, in the town represented by the speaker before we had filtered the water supply, our typhoid rate was high. After we had the filtration plant, every case was investigated by our department, and the result was that if there was any little rise we always found that the milk was more to blame than anything else; in fact, in three cases the milk was traced to one family who lived on one farm on two of the occasions and another time on a different farm. In that case the people sold the milk to a town man, and the town man's wife contracted the fever. It was not reported until possibly one hundred cases had occurred and thirty secondary cases. If you follow that up you will find that the majority of the typhoid in the cities that have filtered water comes from impure milk and lack of sanitation rather than from the water.

As to the hypochlorite, we also found that by applying the 0.5 per cent solution as it comes into the intake well, we get the best results. It also lessens the quantity of alumina to be used, and corrects many of the troubles that were formerly experienced in the operation of our mechanical filter plant.

When you have a plant with the yearly averages for 1910 and 1911 of 99.94 per cent elimination of bacteria, the daily number remaining in the filtered water being 5 and 7 respectively, it is well shown what can be done when it is used properly and with water containing the chemicals that cause the proper reaction of the applied hypochlorite.

Mr. F. B. Leopold: In regard to the statement of the gentleman concerning the percentage of typhoid due to lack of general sanitation, the speaker did not hear the exact language used in his paper,

but gathered, that the claim that improvement in general sanitation is responsible for the greater reduction in the typhoid fever rate in towns that have pure water supply is since the installation of those water supplies?

Mr. D. D. Jackson: Yes; since the installation of pure water supplies.

Mr. F. B. Leopold: There has certainly not been the improvement in general sanitation that there has been in water supplies; and the speaker cannot see the ground of the general improvement due to general sanitation which would apply to those cities which have improved their water supply that should not equally apply to other cities which have not improved their water supply; in other words, if that reduction is due to improvement of general sanitation, why is not the improvement in the typhoid rate equally as marked in cities that have not improved their water supply?

Mr. D. D. Jackson: In cities where the typhoid comes from the water supply there is a very high rate, and the greater portion, you might say two-thirds or three-fourths, has come from the water supply. Just as soon as you cut out the water supply and consider the rates from the other point of view, then the percentages naturally fall very differently and the fall rise in typhoid becomes very marked. This fall rise is marked in New York and Boston, cities not having any material changes in their water supplies. The two cities which were shown were New York and Boston where the fall rise had been very materially reduced. There has been no filtration in those cities and no particular improvement in the water supply. The speaker might also have stated that in a chart of sixteen cities all over 100,000 inhabitants having filtered water there was a steady reduction in rate which is no doubt due to improvements in general sanitation which is going on all the time. If they continue we will get down to the point reached by the German cities where our rate will be almost negligible and there will be no fall rise. There is no fall rise in those cities where there are no privy vaults or exposed excreta. In those cities you will find every house, both in the city and suburbs, connected with a sewer and the sewerage properly disposed of.

Mr. F. H. Stover: We have secured about 60 per cent reduction in the typhoid fever death rate since the filter has been operated.

That covers practically three full years. There are also many public street wells in use some of them badly polluted, and untreated river water is used for drinking purposes on the excursion steamers running on the river. We get the high point in the typhoid during the ate summer and fall.

President Gwinn: Do you tabulate the cases occurring among users of filtered water separately from those that get water from wells?

Mr. F. H. Stover: That has not been followed up.

Dr. Edward Bartow: Results are not always seen immediately, for it takes sometime after the installation of a water supply to persuade people to use it. They are unwilling to change to the general supply, and even after several years may cling to the wells or some other supply. The city of Rock Island has recently installed a good filter plant, but it has taken the people of that city at least a year to realize that they have good water, and many are not using the good filtered water at the present time. Evidently the improved water supply has done something, for during February, March and April of last year the typhoid fever case rate was 141, with 14 deaths; this year during the same period there was only one case and no deaths.

Mr. W. F. Wilcox: One of the most valuable features of Mr. Jackson's paper was bringing out the fact that the water supply might be the cause of typhoid rise in the spring, and bad general sanitary conditions the cause of the typhoid rise in the fall. The majority of the water plants in the United States do not have a magnificent corps of experts such as New York City and Cleveland have. There is many a faithful little fellow struggling in the small town by himself trying to find out if the water is all right and whether he is doing the right thing by the city. If the superintendents of the small plants when they go home will examine their death records and ascertain how far those records in the smaller towns bear out this statement of Dr. Jackson's they will, the speaker believes, discover a method by which they can very cheaply solve the question as to whether the water supply is responsible. Then when they come here next year and bring in the data thus obtained it would be a great weapon with which to go before the mayors and councils of the different towns and prove to them the difference between a bad water supply and a good

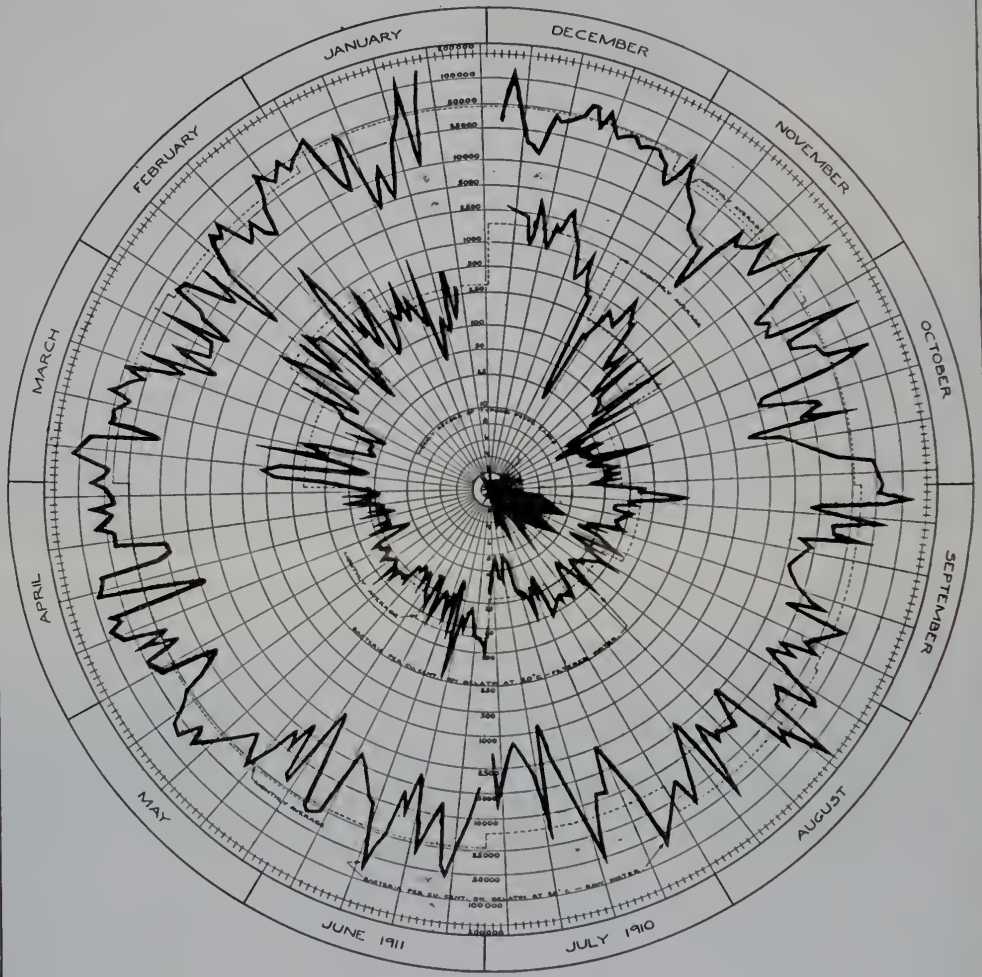


CHART SHOWING BACTERIAL EFFICIENCY OF
FILTRATION SYSTEM AND SEASONAL
RELATION TO TYPHOID FEVER CASES.

WATER DEPARTMENT

WILMINGTON, DELAWARE

JOHN A. BELL, CHIEF ENGINEER

SCALE OF BACTERIA, GROUP 2 NATURAL
LOG. OF NUMBER SUPERADDED TO NUMBER.

SCALE OF TYPHOID GROUP 2 ONE CASE = 2.5 INCHES.

MAR. 1911.

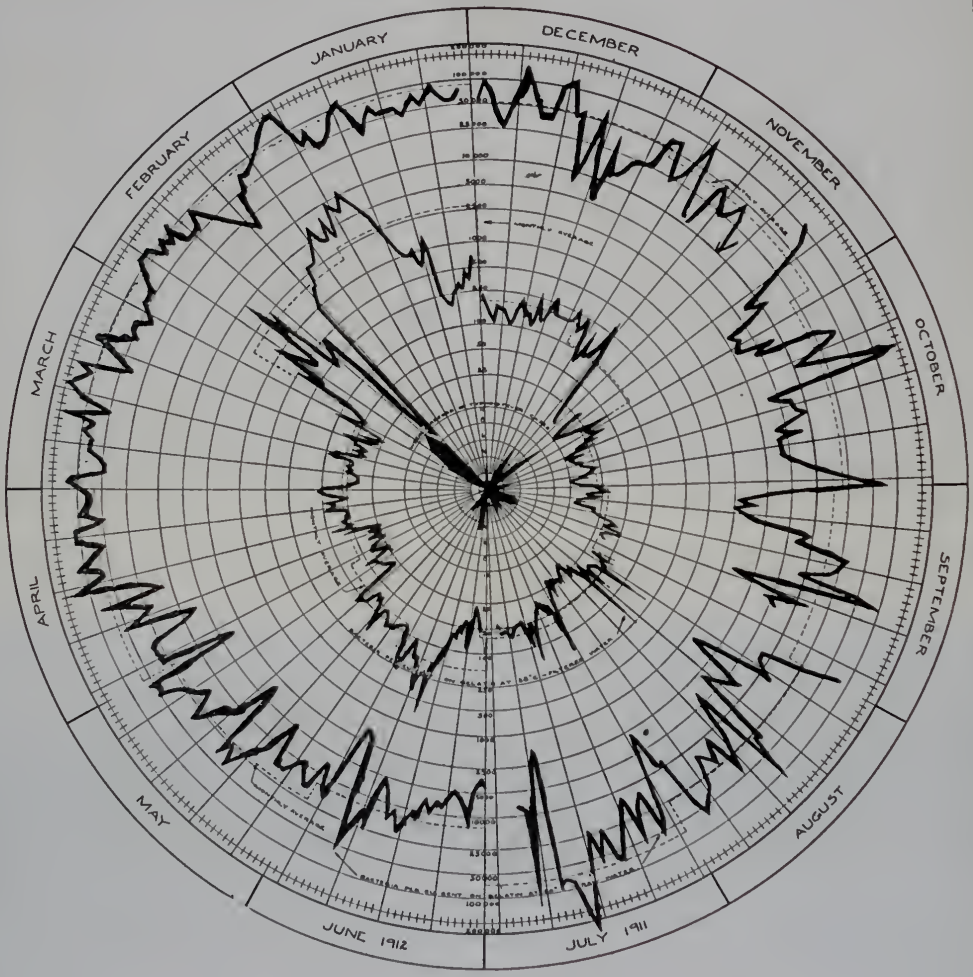


CHART SHOWING BACTERIAL EFFICIENCY OF
FILTRATION SYSTEM AND SEASONAL
RELATION TO TYPHOID FEVER CASES

WATER DEPARTMENT

one and between sanitary and unsanitary methods. It will be a great move forward in the water supply business.

Mr. John A. Kienle: The experience in the town the speaker represents is similar to that explained by Mr. Jackson. A filtration plant was installed and put into operation about two years and four months ago. During the first year's operation we noticed the typhoid situation, particularly during the summer months, did not materially improve. In the endeavor to discover why that was the case, at the close of the year the speaker plotted a rather interesting chart. This chart was plotted on a logarithmic scale in a circular manner, giving detailed results of the entire year as to the number of bacteria on gelatine in the raw and filtered water. It was made on a logarithmic scale because of the fact that the bacteria in the raw water ran up sometimes as high as 200,000 per c.c. The bacteria in the filter effluent tap water was also plotted and of course the curve naturally fell toward the center of the chart. Following that we started to plot the number of deaths from typhoid fever, but it was practically impossible to show very good results in that connection with the chart owing to the elapsed time between deaths, the record of cases was therefore used. These were not plotted daily because the cases were not reported for several weeks, and we finally plotted the total for each week. After the chart was completed we found that during the spring there had been very little typhoid, but during the summer, starting with July and through August and September, the typhoid rate immediately went up, while at the same time the number of bacteria in the effluent from the filter and the tap water delivered to the city was at the minimum. During the winter months when the filter operation was not as good as during the summer months the typhoid rate was again very low, that is during the months of December, January and February, while the bacteria during that time were higher than normal. This showed distinctly the non-relation between the quality of the filtered water delivered to the citizens and the typhoid. The speaker calls particular attention to the fact that during the months of July, August and September, when the quality of the water, indicated by the bacterial plots and confirmed by the presumptive tests for B. Coli, was at a minimum the typhoid rate was high.

Mr. M. N. Baker: The speaker only wishes to renew the suggestion that he has made on previous occasions to this association,

namely, that the water works men continue to place upon the local health departments in the various cities the responsibility of finding out what the distribution of cases of typhoid fever is. A health department should not stop in its efforts to locate the causes and the distribution of typhoid by cases, but it should take more effective steps than are ordinarily taken to eliminate the causes. When pure water has been introduced it should be the duty of the health department to see—and if it has not the power by legislation to do so it should continue to agitate the matter until it gets such power—that the public water supply is used and privies and cesspools abolished. Unfortunately, in the smaller communities, as well as in many of the larger ones, the health departments have not the backbone to use even the legislative powers that they have. In some states the local boards of health have no specific authority; and where they have not they should obtain it. If they have it they should exercise it, and see that the privies and cesspools are abolished and that sewer connections are made and the public water supply used. Such action is not always popular, but should be taken nevertheless. Where there are delays in extending the water supply then the measures suggested by Mr. Jackson for screening privies and screening houses and protecting food exposed in grocery stores and butcher shops should also be followed out, and always particular attention be given to public market supplies.

President Gwinn: We are very glad that you brought up that question, Mr. Baker; and will ask you if you please to present a resolution setting forth your ideas, which can be sent out by this association providing the convention adopts your resolution, and forward it to the state boards of health. It would not be very much of a task to ask the state boards of health to take measures to put these matters into effect; they are practical matters of great value, and they should be placed before the people. The speaker therefore asks that you prepare a resolution of that kind and present it before the close of this convention.

Mr. W. W. DeBerard: Mr. Gwinn asked about tastes and odors. That brings up a subject that is often troublesome and from which more complaint arises than from any other source. In a great many cities hypochlorite is introduced into the water from three to six months, perhaps even a year, before anybody in the town knows anything about it, except those who are particularly interested, that is to say the health and water departments and the other authorities.

Now why do we get these tastes and odors? There seems to be a great difference of opinion on the subject. At the last meeting of the Illinois Water Supply Association when this question came up, Mr. Wm. G. Clark of Toledo made the observation that monocarbonate was quite often present in the Maumee River, running at times as high as 42 parts per million. When CO_2 was absent, hypochlorite could be detected in the smaller doses. However, if applied after using aluminum sulphate which releases CO_2 they were able to use at the Toledo plant any reasonable amount of hypochlorite without getting tastes and odors.

Mr. E. E. Davis: At Richmond we have a law which gives the superintendent of the water works jurisdiction over sixteen miles of watershed, and he is required to have it inspected twice a year, the inspection being done by the chemist who has charge of the settling basin. When troubles are found they are reported to the chief health officers, whose business it is to see that the troubles are eliminated. We have a chief health officer who has the backbone to do that, too.

President Gwinn: We are glad to hear that. That is not always the case.

THE COST OF LEAKS; DOES IT PAY TO STOP THEM?

By Edward S. Cole

Our nation-wide movement toward the conservation of natural resources has given to water works men a new interest in the curtailment of water waste, especially during the last few years and it is hoped that these notes may present some phase of an old subject in a new light.

Water works leakage may be classified as follows: In pumping plants—(a) Plunger leakage, (b) Valve leakage.

Such leaks are known as slippage, causing loss of pump capacity, steam and fuel. Also excessive station use for condensers, etc., should be included here.

All water works plants, whether pumping or gravity, suffer loss of product in distribution by: (a) Underground leakage from mains and services, (b) House fixture leakage—defective plumbing, (c) Misuse to save ice in summer or to prevent freezing in winter, (d) Steals by large metered consumers.

Almost every water works manager contends with some or all of the above classes of leakage and he must do one of two things—either allow the leaks to continue at whatever cost—or, spend time and money in stopping them. Evidently either alternative is expensive and the conscientious official wants to know which will cost him least.

In a pumping plant we should first know the pump-leakage. If tests show 15 per cent, as in Chicago, and we assume that well made pumps should operate with a slippage under 5 per cent, then there is a loss of pump capacity, steam and fuel of fully 10 per cent, which under Chicago conditions costs, $35,000 yearly for coal alone.

Probably the most serious loss involved in pump slippage is that of fire capacity, especially during hours of maximum draft. The neglect of pump-leakage has in many cities led to the purchase of additional machinery and boilers long before such extensions were really needed. In this way are incurred unnecessary fixed charges which may also be considered as part of the cost of leakage.

As for losses from the distribution system, we now doubt the old saying that *"leaks always show on the surface."* Systematic water

waste surveys conducted in Chicago, Memphis, Yonkers, Indianapolis, Washington and New York City have brought to light an immense number of underground leaks running continually into nearby sewers, without showing at the surface. In the city of Washington alone, in the past five years, a total of 30,000,000 gallons daily from about 3000 underground leaks were found, chiefly in mains and service pipes, none of which showed on the surface. A new water supply of this amount would have cost $5,000,000, plus extra operating expenses for the new plant, while the stopping of these leaks actually reduced the operating charges.

By the courtesy of Superintendent W. A. McFarland, of the Washington Water Department, the writer is able to present the following analysis of 2600 underground leaks, found by him prior to October 28, 1911:

	Gallons Daily
1,373 service pipe leaks	13,669,000
607 main joint leaks	8,076,000
620 miscellaneous leaks	5,520,000
Total, 2,600 leaks	27,265,000

Without giving the entire list of the 2600 underground leaks, the following will serve as examples, including the largest leaks reported by Superintendent McFarland:

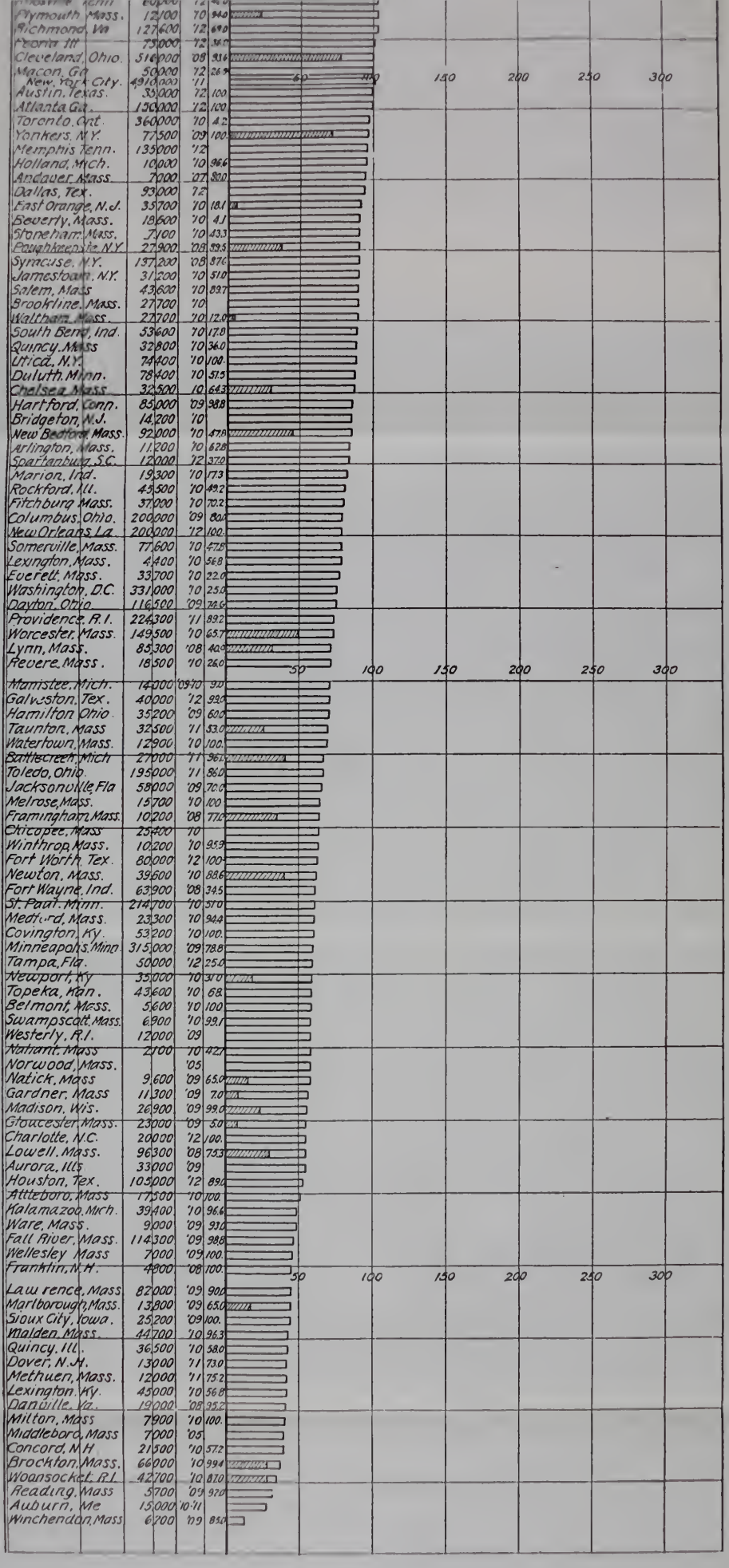
	Gallons.
G St., between 21st and 22d Sts., N. W., def. 4-in. plug	165,000
9th St., between F and G Sts., N. E., def. 6-in. joint	140,000
Washington Navy Yard, abandoned 2-in. service pipe	230,000
Capitol grounds, blow-off valve open	737,000
C St., between 9th and 10th Sts., N. W., broken 6-in. main	302,000
9th St., and B St., N. E. (first high service), def. 6-in. joint	141,000
21 1st St., N. E., def. 2d abandoned service pipe	150,000
5th and T Sts., N. W., 6-in. joint blown out	132,000
N. H Ave. and Dupont Circle, N. W., 4 def. 6-in. joints	109,000
Alley between 12th and 13th Sts., and R and S Sts., N. W., blow-off on 4-in. main partly open	150,000
10th and S Sts., N. W., def. abandoned tap	135,203
2d and U Sts., N. W., def. 48-in. joint	180,000

Pressures are reduced through extra friction loss caused by forcing through the mains so much more water than reaches the consumers. In a great city where pressures are low this extra friction loss may represent the difference between the first floor and second floor supply in thousands of homes, these families pay the penalty of neglected leaks, and the cost is heavy.

WATER CONSUMPTION OF CITIES.

CONSUMPTION : Metered. Un-Metered.

CITY.	POP.	DATE	PER CT Tops Metered	GALLONS PER CAPITA DAILY. 0 50 100 150 200 250 300
Buffalo, N.Y.	423700	'11	4.0	
Salt Lake City.	57800	'06	2.0	
Waco, Tex.	25000	'12		
St. John, N.B	46000	'08	3.2	
Kingston N.Y.	25900	'08		
Albany, N.Y.	100200	'10	23.8	
Chicago, Ill.	2185200	'11	6.0	
Erie, Pa.	66500	'10	2.5	
Pittsburg, Pa.	363000	'06	18.0	
Bridgeport Conn.	82000	'06	5.0	
Philadelphia, Pa.	1599000	'10		
Port Huron, Mich.	34700	'10		
Springfield, Ill.	25000	'09	17.8	
Grand Rapids, Mich.	81000	'10	42.0	
Mobile, Ala.	63000	'12	10.0	
Charleston, S.C.	25000	'12	3.7	
Peabody, Mass.	12600	'09		
Auburn, N.Y.	34600	'11	5.3	
Lafayette, Ind.	20000	'10	9.0	
Camden, N.J.	80000	'08		
Savannah, Ga.	65000	'12	2.0	
Augusta, Ga.	45000	'12	5.0	
Jersey City, N.J.	267700	'10	9.0	
Columbia, S.C.	27000	'12	10.0	
Jackson, Miss.	21600	'12	15.0	
Greensboro N.C.	9000	'12	6.0	
Bangor, Me.	24800	'07-08		
New London, Conn.	19300	'10	15.0	
Pawtucket, R.I.	50000	'08	83.6	
Lancaster, Pa.	45000	'06	30.0	
Binghamton, N.Y.	48400	'10	29.0	
Woburn, Mass.	15200	'10	2.8	
Atlantic City, N.J.	37500	'06	78.4	
Montreal, Can.	321300	'09		
San Antonio, Tex.	100000	'12	16.0	
Boston, Mass.	674400	'10	20.0	
Cincinnati Ohio.	360000	'10	32.8	
Perth Amboy, N.J.	40000	'10	29.0	
New Brunswick, N.J.	23300	'10		
Meridian, Miss.	20000	'12	74.0	
Evansville, Ind.	69600	'10		
North Adams, Mass.	23000	'09		
Reading, Pa.	98500	'08-9	11.9	
Baltimore, Md.	575000	'09		
Schenectady, N.Y.	72800	'09		
Nashville Tenn.	100000	'12	74.0	
Springfield, Mass	87500	'10	6.08	
Indianapolis, Ind.	150000	'09	5.0	
Wilmington, Del.	87500	'10	34.3	
Haverhill Mass.	42000	'10	17.1	
Harrisburg, Pa.	64100	'11	81.0	
Kansas City, Mo.	250000	'10-11	44.5	
Milwaukee, Wis.	385000	'11	81.5	
St. Louis, Mo.	687000	'10	66	
Louisville, Ky.	207600	'10	8.7	
Met. Water Board.	1022200	'10	37.6	
Pittsfield, Mass.	32000	'10		
Newark, N.J.	331000	'09	49.2	
Bayonne, N.J.	55500	'10	99	
Holyoke, Mass.	56900	'10	9.0	
Cambridge, Mass.	100000	'10	38.0	
Knoxville, Tenn.	60000	'12	42.0	
Plymouth, Mass.	12100	'10	94.0	
Richmond, Va	127600	'12	69.0	
Peoria, Ill	73000	'12	36.0	
Cleveland, Ohio.	516000	'08	93.6	
Macon, Ga.	50000	'12	26.5	
New York City.	4910000	'11		
Austin, Texas.	35000	'12	100	
Atlanta Ga.	150000	'12	100	
Toronto, Ont.	360000	'10	4.2	
Yonkers, N.Y.	77500	'09	100	
Memphis Tenn.	135000	'12		
Holland, Mich.	10000	'10	96.6	
Andover, Mass.	7000	'07	80.0	
Dallas, Tex.	93000	'12		
East Orange, N.J.	35700	'10	18.1	
Beverly, Mass.	18600	'10	4.1	
Stoneham, Mass.	7100	'10	43.3	
Poughkeepsie, N.Y.	27900	'08	89.5	
Syracuse, N.Y.	137200	'08	87.0	
Jamestown, N.Y.	31200	'10	51.0	
Salem, Mass	43600	'10	83.7	
Brookline, Mass.	27700	'10		
Waltham, Mass	27700	'10	12.0	
South Bend, Ind	53600	'10	17.0	
Quincy, Mass	32800	'10	36.0	
Utica, N.Y.	74100	'10	100	
Duluth, Minn.	78400	'10	31.5	
Chelsea, Mass.	32500	'10	64.5	
Hartford, Conn.	85000	'09	98.8	
Bridgeton, N.J.	14700	'10		
Newtonford, Mass	9200	'10	47.1	
Arlington, Mass.	11700	'10	62.8	
Spartanburg, S.C.	12000	'12	37.0	
Marion Ind	19300	'10	17.3	
Rockford, Ill	44500	'10	49.2	
Fitchburg Mass.	37000	'10	30.7	
Columbus, Ohio	200000	'09	83.6	
New Orleans La	200000	'12	100	


Plymouth, Mass. 12,100 '10 94.0
Richmond, Va 127,600 '12 69.0
Peoria Ill 75,000 '12 36.0
Cleveland, Ohio. 560,000 '08 93.6
Macon, Ga 50,000 '12 26.9
New York City. 4,910,000 '11
Austin, Texas. 33,000 '12 100.
Atlanta Ga. 150,000 '12 100.
Toronto, Ont. 360,000 '10 4.2
Yonkers, N.Y. 77,500 '09 100.
Memphis Tenn. 135,000 '12
Holland, Mich. 10,000 '10 96.6
Andover, Mass 7,000 '07 80.0
Dallas, Tex. 93,000 '12
East Orange, N.J. 35,700 '10 18.1
Beverly, Mass. 18,600 '10 4.1
Stoneham, Mass. 7,100 '10 43.3
Poughkeepsie N.Y. 27,900 '08 99.5
Syracuse, N.Y. 137,200 '08 87.0
Jamestown, N.Y. 31,200 '10 51.0
Salem, Mass 43,600 '10 89.7
Brookline, Mass. 27,700 '10
Waltham, Mass. 27,700 '10 12.0
South Bend, Ind. 53,600 '10 17.8
Quincy, Mass 32,800 '10 36.0
Utica, N.Y. 74,400 '10 100.
Duluth, Minn. 78,400 '10 51.5
Chelsea Mass 32,500 '10 64.3
Hartford, Conn. 85,000 '09 38.8
Bridgeton, N.J. 14,200 '10
New Bedford Mass. 92,000 '10 47.0
Arlington, Mass. 11,200 '10 62.8
Spartanburg, S.C. 12,000 '12 37.0
Marion, Ind. 19,300 '10 17.3
Rockford, Ill. 45,500 '10 49.2
Fitchburg Mass. 37,000 '10 70.2
Columbus, Ohio. 200,000 '09 80.0
New Orleans La 200,000 '12 100.
Somerville, Mass. 77,600 '10 47.5
Lexington, Mass. 4,400 '10 56.8
Everett, Mass. 33,700 '10 22.0
Washington, D.C. 331,000 '10 25.0
Dayton, Ohio. 116,500 '09 72.0
Providence, R.I. 224,300 '11 89.2
Worcester, Mass. 149,500 '10 65.7
Lynn, Mass. 85,300 '08 40.0
Revere, Mass. 18,500 '10 26.0
Manistee, Mich. 14,000 '09 10 90.
Galveston, Tex. 40,000 '12 93.0
Hamilton Ohio 35,200 '09 60.0
Taunton, Mass 32,500 '11 53.0
Watertown, Mass. 12,900 '10 100.
Battlecreek, Mich 27,000 '11 96.1
Toledo, Ohio. 195,000 '11 86.0
Jacksonville Fla 58,000 '09 70.0
Melrose, Mass. 15,700 '10 100.
Framingham, Mass. 10,200 '08 77.0
Chicopee, Mass 25,400 '10
Winthrop, Mass. 10,200 '10 95.9
Fort Worth, Tex. 80,000 '12 100.
Newton, Mass. 39,600 '10 88.6
Fort Wayne, Ind. 63,900 '08 34.5
St. Paul, Minn. 214,700 '10 57.0
Medford, Mass. 23,300 '10 94.4
Covington, Ky. 53,200 '10 100.
Minneapolis, Minn 315,000 '09 78.8
Tampa, Fla. 50,000 '12 25.0
Newport, Ky 33,000 '10 37.0
Topeka, Kan. 43,600 '10 68.
Belmont, Mass. 5,600 '10 100.
Swampscott, Mass. 6,900 '10 98.1
Westerly, R.I. 12,000 '09
Natiant. Mass 2,700 '10 42.1
Norwood, Mass. '05
Natick, Mass 9,600 '09 65.0
Gardner, Mass 11,300 '09 7.0
Madison, Wis. 26,900 '09 99.0
Gloucester, Mass. 23,000 '09 5.0
Charlotte, N.C. 20,000 '12 100.
Lowell, Mass. 96,300 '08 73.3
Aurora, Ills 33,000 '09
Houston, Tex. 105,000 '12 89.0
Attleboro, Mass 17,500 '10 100.
Kalamazoo, Mich. 39,400 '10 96.6
Ware, Mass. 9,000 '09 93.0
Fall River, Mass. 114,300 '09 98.8
Wellesley Mass 7,000 '09 100.
Franklin, N.H. 4,800 '08 100.
Lawrence, Mass 82,000 '09 90.0
Marlborough, Mass. 13,800 '09 65.0
Sioux City, Iowa. 25,200 '09 100.
Malden, Mass. 44,700 '10 96.3
Quincy, Ill. 36,500 '10 58.0
Dover, N.H. 13,000 '11 73.0
Methuen, Mass. 12,000 '11 75.2
Lexington, Ky. 45,000 '10 56.8
Danville, Va. 19,000 '08 35.2
Milton, Mass 7,900 '10 100.
Middleboro, Mass 7,000 '05
Concord, N.H 21,500 '10 57.2
Brockton, Mass. 66,000 '10 99.4
Woonsocket, R.I. 42,700 '10 81.0
Reading, Mass 5,700 '09 97.0
Auburn, Me 15,000 '10-11
Winchendon, Mass 6,700 '09 85.0
50
100
150
200
250
300

The production cost of water in each particular plant is, of course, the principal basis for estimating the cost of leaks, but there are other elements of value, which the writer wishes to emphasize. The factors determining the cost of water as produced and distributed are too well known to be described here, involving the items of labor, supplies, general expense and repairs for each of the great divisions: (a) Purification works, (b) Pumping station, (c) Distribution system. In addition we should always include overhead charges, interest, sinking fund, depreciation and repairs.

We find a wide variation in the cost per thousand gallons daily ranging from 3 cents to 10 cents in large plants, while in smaller, less favorably situated, the cost may often run as high as 40 cents, or higher. Hence, it is useless to generalize or even to give the average cost of water in American cities.

We are familiar with the ordinary items of expense which have been mentioned, but there are other factors which affect the cost of leaks. To take a concrete example:

In the case of Chicago, the water survey engineers have found that the works pump and distribute more than twice as much water as reaches the consumers; it is apparent, therefore, that the elimination of leakage would produce a three-fold advantage: (1) In saving about one-half the fuel, (2) Increasing pressures by reduced friction loss, (3) Producing reserve capacity for future growth, thus postponing needed extensions.

To any one familiar with the rate of expenditure for extensions in a great city like Chicago, it is evident that this last item far exceeds all the others in determining the cost of leaks.

Still another basis of value was suggested by the manager of a large private water company last summer, who, during a period of drought, was at his wits' end to know how to provide a water supply, not to mention adequate fire protection. At such times of "peak load" the real cost of leakage assumes extraordinary proportions.

As for steals, it is comparatively easy to appraise the cost of a leak due to theft on the premises of large metered consumers. Such "leaks" are more common than many suppose and when detected usually result in the payment of meter rates.

Having attempted to show that the cost of maintaining a water supply is largely affected by leakage, it is natural to ask how we may determine the extent of leakage in a given city. The writer has compiled a list of water consumption figures (see table 1) from the latest available reports of 166 American cities arranged in order of per capita consumption.

This list illustrates the great variation in total use as commonly reported. It is interesting to compare this table with the water consumption of British cities, which the writer has taken from a recently published official directory. We should remember that English cities use few meters, but depend upon the efficient Deacon system of district tests to control leaks.

TABLE 2

Water consumption of the larger British cities

CITY	POPULATION 1911	U. S. GALLONS PER HEAD DAILY	
		Domestic	Trade, etc.
Aberdeen	163,681	36.0	14.4
Accrington	92,000	19.3	6.9
Airdie, Coatbridge	100,000	30.0	15.7
Barrow-in-Furness	84,500	32.0	22.2
Bath	74,000	22.7	3.3
Belfast	390,000	29.8	15.6
Birkenhead	115,257	29.8	11.3
Birmingham	837,776	17.9	11.4
Blackburn	143,000	16.9	8.9
Bradford	288,505	27.0	25.8
Brighton	200,000	30.0	8.4
Bristol	379,923	30.4	
Burnley	105,000	22.3	5.5
Cardiff	236,000	16.9	14.5
Carlisle	56,000	25.7	11.2
Chester	54,000	38.9	8.4
Colne Valley	106,000	25.2	
Coventry	101,000	18.7	4.3
Croydon	169,559	27.6	6.0
Darlington	55,000	25.2	
Derby	130,000	19.6	10.0
Devonport	75,000	35.3	15.7
Doncaster	54,188	28.0	14.0
Edinburgh and Leith	477,000	33.4	8.4
Exeter	63,000	26.4	9.6
Glasgow	1,134,454	44.5	27.6
Great Grimsby	90,000	24.0	8.4
Halifax	110,000	18.0	15.6
Huddersfield	152,000	19.2	12 0
Hull	246,435	36.4	12.5
Ipswich	76,600	19.9	6.2
Leeds	490,985	23.4	1.5
Leicester	282,905	16.0	7.4
Lincoln	60,500	22.0	7.0
Liverpool	958,446	22.4	13.3
Manchester	1,200,000	24.0	18.0
Merthyr Tydfil	90,000	31.2	15.6
Metropolitan Water Board (London)	7,079,251	30.0	7.4
Newcastle-on-Tyne	585,000	19.5	16.2
Northampton	120,000	15.2	3.7
Oldham and District	231,787	19.2	9.6
Oxford	60,000	28.8	4.8
Plymouth	136,568	34.1	

TABLE 2—Continued

CITY	POPULATION 1911	U. S. GALLONS PER HEAD DAILY	
		Domestic	Trade, etc.
Pontypridd	125,000	34.8	4.8
Preston	130,000	30.0	16.8
Reading	97,877	24.9	14.4
Rochdale	125,000	18.0	6.0
Rotherdam	100,000	17.3	6.2
St. Helens	90,000	25.2	15.6
South Hants District	97,415	24.8	
South Staffordshire	701,515	19.7	5.4
Staffordshire Potteries	320,000	19.2	7.2
Stockport	170,000	21.6	6.0
Sunderland & South Shields	425,000	16.8	7.2
Swansea	120,000	42.6	12.3
Swindon & District	56,000	13.1	
Tees Valley	260,000	20.0	50.4
Wigan	95,221	19.5	6.7
Ystrad	75,000	23.4	(3/4)

It is reasonable that we should ask ourselves why there is this great variation among our American cities and between American and English cities in the use of water. The per capita consumption in this country is almost invariably reported as the total use. We ump together indiscriminately public use, business use and domestic use, which is obviously unfair if comparisons are to be made. In England, on the contrary, the water consumption is usually reported for domestic as distinct from other uses.

It is evident that the water used for trade purposes in all British cities is small compared with a few available records of manufacturing use in American cities, but the writer believes that domestic consumption in English cities is not so much lower than it is in many of our own metered cities, if only, we will separate domestic consumption from all other use.

A movement should be started in this country to provide the much needed segregation of uses in our water works reports and it is to the interest of all water works men that this data should be forthcoming as rapidly as possible. Our water works literature is rich in meter statistics and these tend to show that domestic consumption in this country need not exceed an actual use of about 30 to 60 gallons per capita daily. Indeed meter readings prove conclusively that the poorer sections of our American cities are using as little as 10 to 15 gallons per capita. We must recognize that there are a few lavish users among the wealthy class in any city, having extensive grounds on which the sprinkler is in continuous operation and having an

elaborate supply of house fixtures, but it must be remembered that this extravagant class is exceedingly limited in number and probably has little effect upon the average use of our large cities. Of course we must expect to find greater economy in the older countries of Europe which long ago felt the pinch of a diminishing water supply such as we are likely to suffer in our turn when our population has become as dense.

Do not let us deceive ourselves by the use of unfair statistics. It is absolutely necessary to know how we compare in domestic use after deducting water for all other purposes. The writer would make a most earnest plea that water works managers report, even approximately, such figures as will help us separate domestic from business use of water. This data would be valuable to every water works man, giving him for the first time the means for demonstrating efficient management and for pointing the way to increased economy through intelligent comparison.

According to such figures as we have, there are 20 American cities showing a per capita daily use for business purposes of from 3 to 70 gallons, most of them using from about 30 to 40 gallons. With this allowance in mind, it is interesting to examine our American list, Table 1, and note that many domestic rates comparable with those of the English cities (Table 2), would remain, after deducting this amount of business use from the totals reported. Of course any such comparisons must be made with care, for business use may vary from nothing in the residential town to a large part of the entire supply in manufacturing centers.

This discussion of reasonable per capita consumption is presented merely as a basis on which to determine whether or not there are excessive leaks in a given city. Without some such basis, many a city is operating wastefully without knowing the truth.

Metered cities are fortunately placed for such an analysis and it should be an easy matter for them to arrive at this necessary basis for comparison. In the fully metered city it is possible to compare the total pumpage on supply with the total registration of all meters. The amount remaining "unaccounted for" is of course the most reliable criterion of leakage which it is possible to obtain. Occasionally we find a city with practically every service metered but accounting for only 50 per cent or 60 per cent of its total supply. The manager of such a plant should entertain no delusion as to the efficiency of his administration. Either he has underground leakage or there is stealing from his mains,—and the one costs as much as the other.

The question, does it pay to stop leaks,—answers itself.

In conclusion the writer has tried to show:

1. What leakage is.

2. That leakage costs far more than the operating expenses, even with overhead charges added, by reason of friction loss and needless extensions of plant.

3. That there is great confusion in the reported per capita use of water in American cities, due to our failure to separate business and domestic consumption, making comparisons unfair or useless.

DISCUSSION

Mr. J. N. Chester: The paper is a very important one and has been compiled in a very elaborate manner. Inspired by the paper the speaker wants to suggest the appointment of a committee on per capita consumption, or perhaps it might be better styled classification of consumption. When we compare the consumption in a residence town with that in a manufacturing town we are comparing two things that are scarcely comparable. There are plenty of towns in this country where manufacturers take an amount of water equal to 200 or 300 gallons per capita for every citizen in the town. The speaker believes that our water works have gotten to the place now where it is possible to at least separate domestic from commercial and factory consumption. He believes we should go no further than that for a while. The speaker wants to suggest a motion here, and he wants some one to repeat it later when we have a larger audience, that a committee on consumption be appointed to gather statistics on per capita domestic, commercial and factory consumption for our records, and hope that the motion will be acted on after an opportunity to discuss it.

Mr. Alexander Potter: The speaker would like to emphasize Mr. Chester's suggestion as to the necessity for such information. Such a committee would take on a broader scope probably than at first might seem apparent. Now take for instance the case of San Antonio, Texas, Mr. Cole gives the per capita consumption there as 150 gallons, which is about correct so far as the water pumpage for the city is concerned; but in that particular case—and the speaker knows it applies to a great number of other cities—there is about three times as much water used by the breweries, by the railroads, and by other private consumers that are not supplied by the water company in

that particular city, all of which should be taken into consideration in figuring up the per capita consumption of any city.

Mr. A. A. Reimer: The speaker has also been investigating this matter in some work that he has been doing, and has sought to get at the figures showing the division of the consumption, having sent out about 340 data sheets. About 170 replies were sent in and out of that number only about 30 showed a division of the total consumption into various classes. He had asked for a division along the lines suggested. This seems to be a very difficult subject to get at and while Mr. Chester's idea is a good one, the speaker feels that the work of such a committee as Mr. Chester has suggested would be almost herculean, because the information in the possession of the majority of our cities is not in such shape that it can be divided accurately and any estimate for such divisions would have to be made most carefully in order to be of any value whatever. In fact, the majority of us who are handling statistics realize how unsatisfactory are estimated amounts.

Mr. J. N. Chester: The speaker's experience at present is that most of the cities are metering everything but domestic consumption. Further, he believes that the information will be furnished to a committee, with all due respect to any individual investigator, far more readily than to an individual. Further, a committee appointed by this body will have the assistance and coöperation of every member of the association, where the individual would not. He believes that if the committee would pursue the subject vigorously they would get a great deal of information every year. He believes too that if we published a standard method of keeping records we could get it more and more widely in use every year. If water works officials when they took their meter readings quarterly would separate domestic, commercial and factory consumption, they would in that way prepare information that would be useful to them and to others. The speaker believes that we should institute a campaign of education, and if we do not get all we want the first year, we will make a beginning, and the second year we will get more, and still more the third year, until in a few years we will have all the members of this association, and not only all the members of this association but all the water works in the country, keeping their books in this way and our annual reports could publish them.

MR. EDWARD S. COLE: The speaker highly appreciates the remarks of the gentleman. The main object of the paper was to stimulate a segregation of water use in American cities.

MR. F. H. SHAW: The speaker would like to ask Mr. Cole what the percentage of leakage was to the total pumpage, referring to the 30,000,000 gallons?

MR. EDWARD S. COLE: Out of a total of about 70,000,000 gallons a day, five years ago when this survey was begun underground leakage had been found amounting to 30,000,000 gallons daily.

MR. WM. LUSCOMBE: The speaker would like to say a word in connection with Mr. Cole's work. Some years ago he had charge of a water works plant in Iowa. Among other things a water survey was made there by Mr. Cole; also, to determine whether or not there was any slippage in the pumps; the engineer was questioned in regard to the efficiency of the pumps and made the statement that there was about 5 or 6 per cent slippage. Through Mr. Cole's work it was found that there was an actual slippage of 27 per cent. Then a water waste survey was made of the distribution system that enabled us to attach meters to the service pipes of consumers who were wasting large quantities of water that we could not find by making a house to house inspection, because when that inspection was made very naturally the taps were closed. But the water waste survey was made at such a time that the consumers were not aware of it, and in that way we discovered that many consumers were wasting enormous quantities of water. The result was that there was a marked increase in revenue and a reduction in operating costs.

MR. T. C. PHILLIPS: The speaker is sure we are all greatly interested in the valuable paper presented by Mr. Edward S. Cole. His suggestion that cities classify their consumption would undoubtedly be of great value in making comparisons. It is important to know how much water is being used by each class of consumers.

Mr. Cole classifies losses under five heads as follows: Slippage, underground loss, plumbing leakage, misuse and steals. We have made determinations of some of these losses in Chicago. In making an analysis of the water consumption the slippage of pumps was estimated at 15 per cent, which gave a net consumption, after deducting

the same, of 190 gallons per capita, or approximately 432,000,000 gallons per day for 1911.

The net consumption was then divided into its factors of use and loss, and for this purpose 190 gallons daily per capita was assumed equal to 100 per cent.

The consumption by frontage was 37 gallons per capita or 19.48 per cent; the consumption by meter was 44 gallons per capita or 23.2 per cent; the consumption for free service was $9\frac{1}{2}$ gallons per capita or 5 per cent. These items show that the water used amounts to $90\frac{1}{2}$ gallons daily per capita or 47.68 per cent of the net consumption.

The portion of the net consumption lost through plumbing leaks was estimated at 38 gallons per capita or 20 per cent. The portion lost through slippage of meters was estimated at $4\frac{1}{2}$ gallons per capita or 2.32 per cent and the portion estimated lost through underground leakage and wastage was estimated at 57 gallons per capita or 30 per cent. These items show that the water lost amounts to $99\frac{1}{2}$ gallons daily per capita, or 52.32 per cent of the net consumption.

The underground leakage and wastage estimated at 57 gallons daily per capita, or 30 per cent of the net consumption, includes use, careless and willful waste, and other losses at night time. This estimate was based upon the minimum night rate of flow into districts where the per cent of metered water was small. Underground leakage can be accurately determined where curb cocks can be closed.

Where services are metered and where curb cocks can be closed, classification of the consumption can be accomplished without difficulty. Such conditions are not always obtainable, but reliable determinations can be made without these favorable conditions as has been demonstrated in a number of cities.

Mr. A. A. Reimer: This subject is one very dear to the heart of the speaker and is one that we are watching and studying constantly in East Orange, where we are seeking by every means to eliminate the waste of water. Our services are not very largely metered, only 25 to 30 per cent, but we are pushing the work of metering for the sake of saving water and reducing the loss by leakage. This movement was materially accelerated by the results accomplished by a water waste survey made a few years ago.

We have used the method of house to house inspection ever since the speaker's connection with the East Orange department and have found it to be of tremendous benefit, and believe that it should be carried out regularly and systematically. Our plan calls for a per-

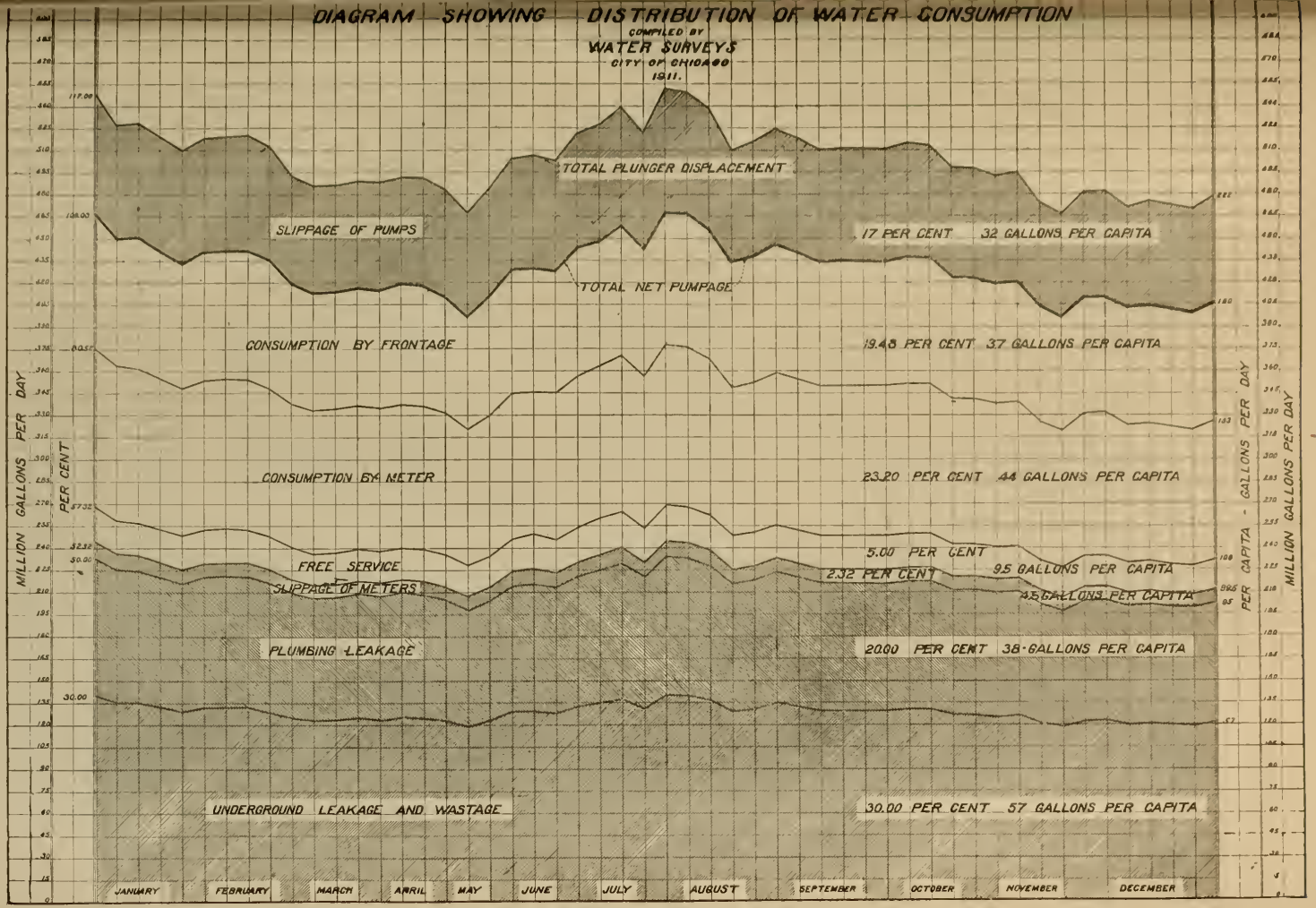


DIAGRAM SHOWING DISTRIBUTION OF WATER CONSUMPTION
COMPILED BY
WATER SURVEYS
CITY OF CHICAGO
1911.
TOTAL PLUNGER DISPLACEMENT
SLIPPAGE OF PUMPS
17 PER CENT 32 GALLONS PER CAPITA
TOTAL NET PUMPAGE
CONSUMPTION BY FRONTAGE
19.48 PER CENT 37 GALLONS PER CAPITA
CONSUMPTION BY METER
23.20 PER CENT 44 GALLONS PER CAPITA
FREE SERVICE
SLIPPAGE OF METERS
5.00 PER CENT
2.32 PER CENT
9.5 GALLONS PER CAPITA
4.5 GALLONS PER CAPITA
PLUMBING LEAKAGE
20.00 PER CENT 38 GALLONS PER CAPITA
UNDERGROUND LEAKAGE AND WASTAGE
30.00 PER CENT 57 GALLONS PER CAPITA
MILLION GALLONS PER DAY
PER CENT
PER CAPITA - GALLONS PER DAY
MILLION GALLONS PER DAY
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

sonal inspection of every building in the city every year to determine the conditions of the plumbing, though we are not always able to cover the entire city in one year with our present force of inspectors. The subject of water waste is vital to us just at the present time because our city is now trying to determine its future course with regard to two possible schemes of sewage disposal, either one of which will mean a very heavy investment for a city of our size. One of the schemes uses the amount of sewage as the basis for determining the city's share, the other scheme involving the tax valuations shown by various municipalities entering into this scheme. As our valuations are very high for the population and our water consumption and consequently the amount of sewage is very low, the scheme using as a basis for cost the amount of sewage is the one for which we are working. Naturally anything we can do toward decreasing the waste of water will also decrease the assessment for the sewage disposal project.

Our consumption is fairly low for a city that is not largely metered, the present average being about 85 gallons per capita daily, the percentage of meters to total services being about 25 per cent. Allowing that the results of the water waste survey made some time ago hold good at the present time, the speaker believes that our consumption can be brought down to about 50 gallons per capita, thus bearing out what Mr. Cole has said as to the relative consumption in our American and the foreign cities.

The speaker hoped to have a paper prepared for this Convention showing a comparative statement of the various elements of consumption in a number of cities of the United States, but the data did not reach him in time to get it in proper shape so that he could segregate the various elements. Mr. Chester's suggestion yesterday appealed to him as being a good one, that a committee be appointed to investigate the question of division, into the proper parts, of the total consumption of our various cities, such as domestic use, commercial or manufacturing use, free water and public uses; and while the speaker does not believe that such a committee could accomplish much in a year, his further suggestion holds good that in the course of time results would accumulate that would be of large benefit to us all should such a committee be maintained for a period of years. It might be well to discuss the question of the formation of such a committee further. Should such a committee be appointed the speaker will be glad to render such service as is possible and if they wish to use any data that he has collected up to the present time they certainly will be welcome to it.

METHODS AND COSTS OF A LEAKAGE SURVEY AT LANCASTER, PENNSYLVANIA

By F. H. Shaw

The city of Lancaster is located in the southeastern part of Pennsylvania on the main line of the Pennsylvania Railroad between Philadelphia and Harrisburg. It has a population of about 50,000 and is the business center of a rich agricultural district.

The city has an area of 4 square miles, about three of which are built up, the houses being constructed of brick with practically solid fronts between streets. This method of construction gives a population of about 25 per acre.

The city is supplied with water by a municipal plant, the first construction dating back to 1836.

The water is taken from the Conestoga Creek, a tributary of the Susquehanna River, having a drainage area of 310 square miles of highly cultivated farming country containing many small towns and a population of 120 per square mile.

The water is filtered and pumped into the city against a head of 250 feet. The distribution system is connected with the pumping station by two force mains, one 30-inch and one 36-inch, each being about 1 mile in length. The distribution system is divided into high and low service districts. The low service district contains about 0.4 of a square mile and is supplied from the old reservoirs constructed in 1836 and in 1850 which have a capacity of 6,000,000 gallons. These reservoirs are filled at night by pumping through the 36-inch main.

The high service district is supplied through the 30-inch main by direct pumping, the water passing through a standpipe having a capacity of 400,000 gallons, located on the reservoir grounds. The distribution system consists of 70 miles of pipe varying in size from 24-inch to 4-inch.

The system has been extended outside the city limits by various small water companies, their supply mains being metered at the city line.

There are about 10,500 services in use, one third of which are metered. All large consumers are metered and meters are being installed at the rate of about 400 per year, all new properties being

metered. The schedule rate for a three-story house having bath, two closets and pave wash is $17. The meter rate is 5 cents per 1000 gallons with a minimum of $10.

The daily consumption averages about 7,000,000 gallons, varying between 5,000,000 and 10,000,000 with a maximum pumping rate as high as 12,000,000 for short periods. Assuming a population of 50,000 this will give a per capita consumption of 140 gallons daily.

This excessive consumption led to an investigation of causes and methods for correcting same. A general house-to-house inspection was made during the winter of 1910, at which time all plumbing was inspected for leakage. The results of this inspection were recorded on a card for each property inspected. As a result of this inspection the yearly income from water rents was increased $3500.

The city was then divided into four districts and a regular inspector appointed for each district. A yearly inspection is made of each house and property owners are compelled to repair all leaky fixtures within ten days, 480 cases being reported and repaired during the last year.

During these investigations the necessity of a systematic search for leakage from mains became apparent and the discovery by accident of a leak which was costing the city about $10,000 per year brought the matter to a head and the necessary appropriation was made.

The survey party was organized from employees of the water department, a foreman who had been in the department for twenty years being placed in charge of the work. The party worked nine hours per day and was composed as follows:

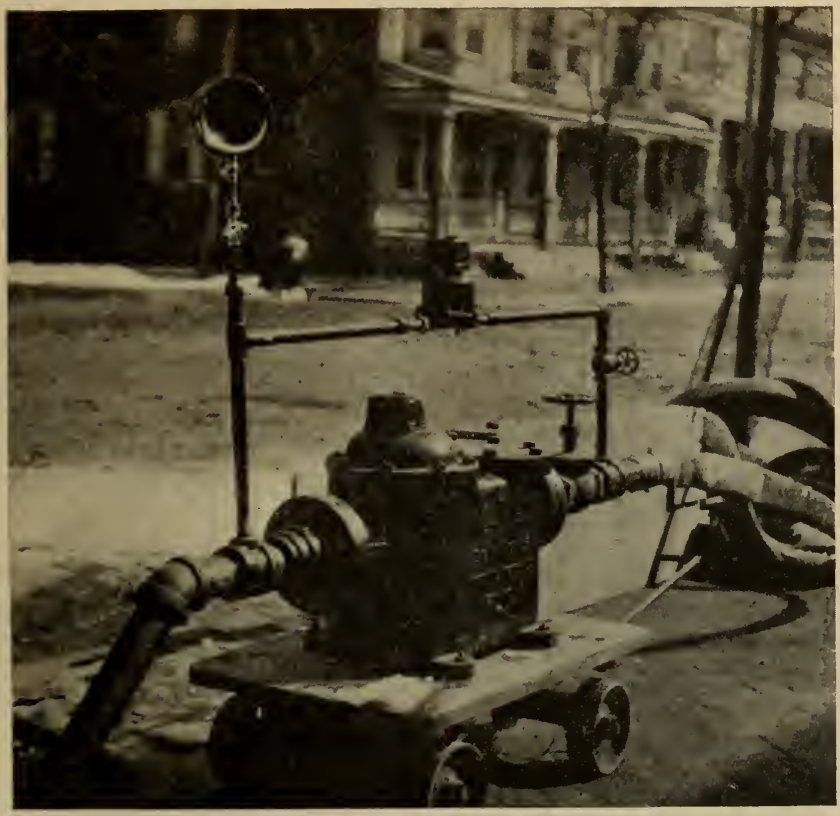
Organization

	Per day
Foreman	$3.00
Single team and working driver	2.50
Three laborers at $1.80 per day	5.40
Total cost per day	$10.90

Outfit

One 4-inch meter with 2½ inch connections, on truck.
One ⅝-inch meter.
One pressure gauge.
Two 25-foot lengths 2½-inch fire hose.
Two hundred and fifty feet 2½-inch galvanized iron pipe.
One small tool box.
Picks, shovels, wrenches, caulking tools, lead wool, etc.

The first step in preparing for this work was an inspection of all valves and repairs to same, placing them in working order and replacing some which could not be operated. This work was done by the men in the distribution department in advance of the survey. The survey was started on March 6, 1911, and stopped for the winter on December 13.



The method of procedure was as follows: The 4-inch meter was mounted on a small four-wheeled truck and the connections bushed down to $2\frac{1}{2}$ inches with a $2\frac{1}{2}$-inch valve at inlet and outlet. The large meter was by-passed by a $\frac{5}{8}$-inch meter for use on small flows. A pressure gauge was attached to the outlet end of the large meter. The districts tested had an average area of 12 acres containing about 80 houses.

The district to be tested was shut off from the remainder of the system by closing all valves on street mains. The meter was then connected with a hydrant outside the district by means of a 25-foot length of fire hose. The $2\frac{1}{2}$-inch pipe line was laid from the meter to a hydrant inside the district, being connected with it by another short length of hose. The consumption of the district was then measured for one hour, readings being taken every ten minutes and any reductions in pressure noted. Any considerable drop in pressure indicates either a large leak or that the district is too large to be supplied through the $2\frac{1}{2}$-inch pipe.

After the consumption had been measured all connections were shut off inside the houses, an inspection of house plumbing being made at the same time. A test was then made to determine whether any street valves were leaking water into the district by opening a fire hydrant and watching for any flow from the opening. After everything was shut off the leakage was measured by the large or small meter according to the amount. This flow, if any, represented the leakage from mains and also from services. To locate the leaks the streets inside the districts were cut out one at a time by closing the valves until the leak had been located between two valves after which it was located by using the telephone on curb stops, hydrants and on drills driven down to the main. After the leak had been definitely located it was dug up and repaired by the survey party and the district tested until found tight.

The work was carried on for 240 days at a cost of about $11 per day or $2640 for the season for labor. The cost of lead wool, etc., for repairing leaks was very small. One hundred and eleven districts were tested having a total area of 1310 acres, or 12 acres per district. There were approximately 9000 houses in the territory covered.

Following are the leaks discovered and repaired:

Residences		
Closets	20	
Yard hydrants	10	
Faucets	19	
Service mains	17	
	—	66
Street valves	12	
Fire hydrants	35	
Street mains	29	76
Total number of leaks		142

The leaks varied from 1 to 19 cubic feet per minute. The largest leak found was a 3-inch elbow split wide open and running at the rate of 205,200 gallons per day. This line had been by-passed around the meter outside the building and was supplying four buildings. In this case the survey not only stopped the leak but detected the illegal use of water. This leak amounted to 75,000,000 gallons per year, the actual cost of furnishing which was $2812.50 or $172.50 more than the cost of the entire survey.

The total mileage of mains inspected was 40.8, varying in size from 4-inch to 24-inch.

The total leakage record was 118 cubic feet per minute or 1,271,000 gallons per day. Using $37.50 per 1,000,000 as the actual cost of furnishing water exclusive of interest, the total leakage was costing the city about $17,000 per year.

About one-quarter of the system remains to be tested, also the 20-inch supply main which runs directly across the city. Work is now in progress on this section.

One mile of 36-inch force main laid in 1888 was tested by closing the valves at both ends, and supplying it from the other force main through a small meter. Leakage was found amounting to $2000 per year. The joints on this main will be dug up and re-caulked during the present season.

The results of the leakage survey were not as apparent as was expected for two reasons, one of which was the exceedingly dry summer and the failure to provide for street sprinkling by wagons, causing a great increase in the use of individual hose sprinklers.

Another reason was the exceedingly cold weather during the winter which caused an excessive use of water to prevent freezing and also damaged many service mains, all of which have probably not been discovered. After the present survey has been completed, some of the districts will be retested to ascertain the damage caused during the past winter.

A comparison of the consumption before and after the survey shows a decrease of 10,000,000 gallons per month during March and April, and equal consumption from May to September, a decrease of 8,000,000 per month during October and November, a decrease of 24,000,000 during December and an increase of 20,000,000 during January, February and March, while the present consumption is about equal to that before the survey began while the consumption for 1911 is slightly less than for 1910.

The writer considers the decrease of 24,000,000 per month shown

in December a fair indication of the results of the survey, as abnormal conditions existed before and after this time which had a tendency to increase the consumption. As an investment he believes a survey of this kind, which not only locates but repairs leaks, is a good one and well worth following up until assured that the distribution system is reasonably tight.

When the work is completed the writer will endeavor to present the final results for your consideration.

DISCUSSION

PRESIDENT GWINN: This is a very interesting paper and gives us the kind of information that we want.

MR. EDWARD S. COLE: The speaker would like to ask how long it took to cover the 10.8 miles?

MR. F. H. SHAW: From March 6 to December 13.

MR. WILLIAM LUSCOMBE: What percentage of the system is metered?

MR. F. H. SHAW: All of the large consumers, practically 33 per cent of the entire system.

MR. R. J. THOMAS: It seems to the speaker that the proper thing to do in this case would be to meter more generally. In the city he represents we have a population of 106,000, according to the census of 1910, and our total average daily consumption for 1911 was 5,240,000 gallons, which is a per capita of less than 50 gallons.

The speaker believes that much of the expense incurred in making a house to house inspection and other work of a similar nature would be spent to better advantage and show far better results as far as the reduction of waste is concerned, in the application of meters to the services.

The speaker is not entirely satisfied with our showing, even though it is a very favorable one for a city of that size to have a per capita of 49 to 50 gallons, and he feels inclined to favor making a survey of the city, as Mr. Cole has described, to see if there are any leaks. There cannot be too much emphasis placed upon the necessity of conserving water and preventing waste. It is of the greatest importance.

Water is our stock in trade, and we ought to see that it is not wasted. The most efficient means of preventing waste and unnecessary consumption is the application of meters. It has resulted in very great benefit in our case. Ten years ago our consumption was 40 per cent greater than it is now, not allowing anything for the increase in population or number of taps. About 78 per cent of our taps are metered, including all our manufactories, business places and fire services, everything except small cottages.

Mr. T. C. Phillips: Mr. Thomas emphasized a point on which the speaker believes nearly all will agree, that money spent for house to house inspections might be more efficiently spent in metering. It is easier to bring about metering in smaller cities than in the larger ones like Chicago. The cost of saving water by district survey and house to house inspection in the city of Chicago amounts to about 1 cent per 1000 gallons saved, based upon a saving of one year. The speaker believes it is well to continue house to house inspection where a liberal policy of metering is not in force. The educational feature of a waste survey is important in a city like Chicago where only 6 per cent of the services are metered and where the per capita consumption is high.

The speaker believes that metering would decrease our present consumption about one-third. Mr. Shaw states that two-thirds of the services in Lancaster are metered and that the consumption is 140 gallons daily per capita. The city of Milwaukee, practically all metered, accounts for about 60 per cent of its consumption.

The speaker feels that Mr. Thomas is correct in his statement that money might be more efficiently spent in metering, provided a city has authority to proceed with metering. In Chicago 94 per cent of the consumers are on a flat rate basis under the ordinances. Our ordinances he believes are far too liberal. Where a city cannot meter it can effect a great saving by district surveys and house to house inspections.

Mr. John A. Kienle: The remarks of Mr. Thomas and of the gentleman from Chicago are very important on this question of house to house inspection cost as compared with spending the same money in another manner, namely, in metering. In Wilmington, Delaware, a house to house inspection has been carried on for a number of years, not every year but at intervals of two, three and five years. We have had meters installed there since about 1892, starting with

the large manufacturers. A meter rate was established at that time which is still in existence. We have not found any material reduction in per capita consumption due to the installations although we have been installing meters regularly every year on both new and old services.

The point that the speaker wishes to bring out in connection with the expenditure that Mr. Shaw referred to by the city of Lancaster in investigating underground leakage and plumbing leakage, in connection with our work in Wilmington, is that our meter rates are such and have been such since meters have been installed, that for domestic consumption it encourages the excessive waste of water through leaking plumbing fixtures; which house to house inspection will prevent. We allow for a $10 minimum on a $\frac{5}{8}$-inch meter a consumption of 300 gallons per day. Actual investigation of the statistics on meters for the year before last showed that 50 per cent of the $\frac{5}{8}$ inch meters on the domestic consumption used but 50 per cent or less of the actual water that they were allowed for this $10 per annum minimum charge. An additional 20 per cent of the $\frac{5}{8}$-inch meters installed on domestic services did not use two-thirds of that allowance of 300 gallons of water per day; or in other words, 70 per cent of the total number of services installed in private dwellings did not use two-thirds of the water that was allowed them for the $10 minimum; this demonstrates that our minimum permits of practically one-third waste through meters before the consumer has to pay for it.

This brings up the question of changing the rates in order to save that wastage which is now permitted to go on before we get any revenue from it. The speaker thinks that all the superintendents and all of the membership of this association connected with water companies realize the difficulty of changing the rate in any city where it has been in force the number of years that it has been in Wilmington. It will raise a hue and cry from the consumer; so it is just a question of whether the money that you would put into metering additional services might not be better spent in the manner that Mr. Shaw has mentioned in Lancaster, or otherwise educate the people to the fact that the rates must be changed unless they exercise more care in the use of water.

Mr. George G. Kennedy: The speaker might tell his neighbor from Wilmington how we do in Harrisburg. We have 83 per cent of our services metered, and a per capita of 117 gallons, of which 68 gallons is used for manufacturing. We have 13,000 houses metered,

at a minimum rate of $6 a year, and a charge of 12½ cents per 100 cubic feet. That gives practically 100 gallons a house, and they pay for waste. As a matter of fact a good way to raise rates is not to raise prices but to cut down the amount. We raised our rates once; the rate had been 10 cents per 1000 gallons, and we made it 10 cents per 100 cubic feet.

Mr. A. A. Reimer: We get around the questions of inspection and metering by combining the two and find this to be a very satisfactory method. The per capita consumption has been lowered materially through metering, the results being already apparent from metering about 2500 taps out of 7500. The per capita consumption three or four years ago was up to 93 to 95 gallons daily, but is now down to 80 to 85 gallons daily, and we have gone on record in public so that we can not go back on it, that the total consumption for the year 1912 will be materially lower than it was for 1911. If that prediction does not hold good the speaker will certainly be a prophet without honor, but he feels sure that it will hold good.

The possibility of arousing a disturbance in our city and encountering severe opposition in an attempt to place meters in large numbers was one that we went into very carefully in East Orange, and we got around it in this way. When the ordinance came up about three years ago the speaker suggested that we deal most carefully with this subject and at that time the prominent clause in the meter ordinance called for the metering of all new services installed after the adoption of the ordinance. Then we worked in a little clause that looked very innocent, to the effect that the board of water commissioners reserve the right to order the metering of any service which in its judgment should be metered because of leakage, excessive use of water, or for any other cause. The clause looked innocent enough but it is the saving feature of the ordinance so far as metering is concerned. Under the provisions of that clause the board later passed a resolution calling for the metering of all two-family or multi-family houses, thus taking in all the large and small apartment houses. We are busy on that class of houses now. The next important step will be the metering of all the single-family houses and this will also be the last step toward making us 100 per cent metered. It is simply a case of metering by classes and this method has been highly successful with us and there has been practically no opposition in this work. The speaker believes you all can accomplish a similar result by a little careful handling of the ordinance under which you act.

MR. F. H. SHAW: Our rate is 5 cents per 1000 gallons, with a minimum of $10. In regard to the stopping of leaks by metering, of course the meter in most cases is in the house, and no matter how many meters you have you will not stop any leaks on house services or pipe lines. A statement should be printed on cards stating what the object of the inspection is and the fact that a large leak costs so much. We had such a blank printed and left one at each house when making the survey, so that the people realized what we were doing. The raising of rates is the end we have in view, but we want to know first that we have a tight distribution system and that there is no waste of water from that source. In most municipal plants there is always an election ahead, and you have to work on your educational problems as far away from election time as you can.

MR. J. A. KIENLE: In reply to Mr. Kennedy's remarks as to the manner in which he raised his rates by cutting down the quantity of water on a minimum charge per year, the speaker might say that we are in an unfortunate position in that respect in that we have a sliding scale of rates which applies to all meters covering manufacturing as well as domestic consumption. This sliding scale ranges from 7.5 cents per 1000 gallons to 35 cents per 1000 gallons, up to 200,000 cubic feet for $75, and a change would have to be made in the entire sliding scale in order to reduce the quantities, since the $10 minimum is based on that sliding scale. The minute we change the sliding scale we affect our manufacturers' rate in its beginning; and since we depend upon the manufacturers to a great extent to increase the population and growth of the city, we have to be a little careful in changing their rate.

MR. GEORGE G. KENNEDY: We make them a separate rate as low as $2\frac{1}{2}$ cents per 1000 gallons.

MR. R. J. THOMAS: The speaker believes the opposition to the general application of meters is overestimated; there ought to be more remonstrance against house to house inspection, people down our way would object more to having a man come in and look over taps and examine them—they would certainly find more fault with that practice—than with the placing of a meter in the house or cellar. We put on 1000 meters at first, at the expense of the city. Since then a majority of these meters have been bought by the owners of the

property so metered, showing that they were well satisfied to buy water that way.

PRESIDENT GWINN: The speaker believes that they would rather have a man go down into the cellar to read the meter than to go up into the bath room to inspect the fixtures.

MR. F. H. SHAW: We have only had to have a policemen in three cases in order to get into the houses.

TO WHAT DEGREE MUST SEWAGE BE PURIFIED?

By Chester G. Wigley

Several articles have been written, which in a more or less general way, have touched upon, or briefly discussed the question of the economical disposal of sewage. By economical disposal of sewage is meant the question of the necessary degree of purification to be attained, when considered in connection with the stream, or body of water into which the effluent will be discharged.

The question is of such importance, and engineers are so often confronted by it, that any discussion, leading to a more defini e general policy in the matter of the limitation of the degree of purification, is sure to be advantageous. For the question arises repeatedly and with increasing importance, as larger areas and populations are affected. Unfortunately, the answer to this question of, "What degree of purification is necessary?" cannot always be readily given, and it will be endeavored in the present paper to outline a general policy which may aid in the solution of the problem.

It is a question, which not only needs careful consideration at the present time, but one which, taking the future into consideration, becomes with increasing population very complex and of paramount importance.

While it does not appear that the economical disposal of sewage has been followed as a definite principle by most of the centralized boards and commissions having jurisdiction over the construction of sewage disposal plants, they have in general taken into consideration matters of environment which would affect the quality of the effluent. These considerations have generally been of a local nature, and have sometimes led to inconsistencies and unfair treatment of different municipalities.

It may truthfully be said, that some disposal plants produce an effluent considerably better than local conditions and the characteristics of the body of water into which the effluent is discharged would warrant. It must, on the other hand, be confessed that such disposal plants are comparatively few in number, as compared with those that do not produce an effluent of as good quality as is demanded by local

conditions. Often there is a local cause for the latter case, and this is the attendant or caretaker of the disposal plant. He is often a political adherent of an unimportant type, and feels that the job must be treated politically, consequently, drawing his salary and using as little gray matter and labor as possible. There are others who are conscientious in their work, but because of duties as superintendent of streets, chief of police, sanitary inspector, or other municipal offices, are hindered in their work at times when they are, to say the least, most urgently needed at the disposal works. There is a third class, who do not know, nor never will know, how to operate a sewage disposal plant in anything like an efficient manner.

It is attendants similar to these, that are dangerous factors to deal with, where a water supply or shellfish layings may be polluted by their lax methods. They have, in many cases, caused considerable odium to be attached to what should otherwise have been satisfactory disposal plants. In general, any ordinary workman, with fair common sense, can and does satisfactorily discharge the functions of an attendant at a small sewage disposal plant, provided that he is well instructed in his duties and can refer matters beyond his ken to some sanitary engineer.

Sometimes it has happened that engineers after designing and constructing a sewage disposal plant will depart without leaving any directions for its proper maintenance. This has, in some cases, resulted in a rapid deterioration of the plant and a consequent pecuniary loss to the municipality.

It is for the above reasons, that one of the chief functions of a board of health or sewage commission should be to see that sewage disposal plants are operated in a satisfactory manner. It is at present one of the most difficult phases of the sewage disposal question, especially in connection with the smaller installations. Irreparable damage may be occasioned by a few moments' neglect and to eliminate as far as possible, such chances of accidental pollution is often a very difficult proposition.

We are, however, not so much concerned from an economic standpoint with the plants that fail to work as we are in those plants that produce an effluent much better than is necessary.

That the latter is sometimes the case and that there are often inconsistencies in the required degree of purification is self-evident. It is even true that on the same streams different degrees of purity are demanded without any apparent reasons for the difference. In some cases this has been the fault of the central authority having jurisdic-

tion over matters of sewage disposal. In other cases it is directly chargeable to engineers who have not investigated as thoroughly as they might the economics of the system to be used. Where the difference is caused by a central authority as a state commission, such treatment of different municipalities can not be considered as just, for one municipality spends much more money than another without improving conditions.

Now, in determining the necessary degree of purification the path is seldom straight and broad, but is narrow and diverges for this or that reason or combination of reasons at any particular place. It is very seldom that any two places dispose of sewage under exactly similar conditions and each varying condition will affect the design of the disposal plant.

This question as to the degree of purification necessary, is in reality the most important point in the design of a sewage purification plant and requires much care and judgment in its determination. In the perplexity of conflicting conditions governing this point, we are often prone to go either far beyond, or considerably short of that degree of purification at which the greatest economy is obtained.

In speaking of the economical design of any disposal plant there are strictly speaking two different questions of economy. The first being that of the relative economy of the various types of any of the units comprising the plant, as for instance, the comparative value of settling, Imhoff, or biolytic tanks, as a preliminary process. Strange to say this question does not always receive the amount of consideration that it should, because of some petty prejudice of the engineer, a favorite one being the tendency to eliminate any patented devices. If the patented devices are worth more than the royalty to be paid they should be used. Another matter which tends to uneconomical methods of disposal is the endeavor of general practising engineers to do without the services of consulting engineers familiar with the various processes of disposal. In some cases general practising engineers called upon to design a disposal plant will obtain the services of a competent consulting engineer. On subsequent installations the general practitioner will consider the first design as applicable and, by working over the plans of the consulting engineer, endeavor to design a new plant. It is, to say the least, a system productive of very poor results, both for the municipality and for the designing engineers.

The other question of economy is that which takes into consideration the general public welfare and the interrelations of groups of

municipalities situated upon the same body of water. It is these relations which are directly affected by the limitation of the degree of purification of sewage and the most economical method of disposal is that in which the best relations may be maintained at the smallest cost.

In the present state of the science of sewage treatment it is possible to produce an effluent of almost any given degree of purification short of absolute sterilization, and when the question as to the necessary degree of purification has been satisfactorily decided, a disposal plant can be readily designed. But in determining this point there is such a complexity of conflicting conditions and so many hypothetical considerations affecting the degree of purification that the difficulty of arriving at a fair and equitable decision can only be appreciated by one who has tried to satisfy two inimical factions.

In connection with the question as to the necessary degree of purification, it would appear that we are fast approaching, if we have not already reached, the point at which the large quantity of sewage from populous districts is compelling a bacterial standard of efficiency rather than that of sight and odor.

This is due in great part to a better realization of peril from bacterial pollution and the relative unimportance of malodorous and unsightly discharges alone. The bacterial standard has been partially forced upon us, as the watersheds used by our older municipalities have been encroached upon by the cities themselves or by newer and smaller inland municipalities and almost unnoticed discharges of filth have caused very serious epidemics. In this manner the public has been brought to a truer realization of the real dangers of the indiscriminate discharge of sewage into streams.

It is also noteworthy that courts and public commissions are, at present, literally construing the terms "pure and potable water" which so often occur in the franchises of water companies. It is not now sufficient that a water be clear and cool, but the purity and potability of a water is measured by and must satisfy certain bacterial standards.

In any case the necessary degree of purification will depend very greatly upon the nature of the body of water into which the effluent is discharged.

We may, therefore, first consider the disposal of sewage with reference to the waters according to their geographical classification such as the ocean, bays, rivers, brooks and lakes. Each of these waters will in turn have its train of conditions greatly depending upon its use,

which must be fulfilled before the system of disposal can be satisfactory. Furthermore any system of disposal must be viewed from the several sanitary standpoints of liability of infections, the causation of nuisances, the effect upon the environment and their relative importance.

For the purposes of this article the only methods of disposal that need be considered are those in which an effluent is finally discharged into some body of water, as they are the only types adaptable to municipal conditions.

In making a geographical division of the waters, there is a merging of one class into the other, which in certain cases of sewage disposal will slightly complicate the problem of determining the limits of the purification process.

THE OCEAN

As to the ocean it is generally conceded that the purification process for sewage discharged into it shall be of a rudimentary nature. This is primarily so, because the ocean is so large that it requires a large amount of sewage to cause even a local nuisance.

A second and more important reason from a sanitary standpoint is that, except in rather limited areas immediately along the shore, ocean water is not of a character suitable for human use in any manner that would be liable to cause the transmission of disease. Oyster beds are never located in the ocean and although clams may be found there, they are not generally of that quality desired for edible purposes. So that practically the principal and almost only opportunity of acquiring disease from ocean discharged sewage is by an inadvertent mouthful during a bath in the surf. While it is possible that disease may be caused in this manner, and probably has occurred, a case has never come to the writer's knowledge.

Another reason tending to make elaborate disposal plants unnecessary is that salt water appears to have the power of more readily oxidizing organic matter than does fresh water.

But, as the only true economic test of any proposition is that of "the greatest good to the greatest number" we may endeavor to apply it here and ascertain what good may be obtained and what degree of purification would be best.

In view of the fact that the ocean can readily assimilate the smaller organic matter of raw sewage in reasonable quantities, it is apparent that any of the processes of sand, trickling, or contact filters would be unnecessary. We are, therefore, only to consider screening, sedimentation processes, and, possibly, disinfection.

In general it will be found that nuisances from sewage discharged at the seacoast may be obviated at such a low cost that, taking into consideration the effect upon surrounding properties and the peace and comfort of the inhabitants, it is economical to prevent them. Where surf bathing is a pecuniary asset it is necessary to remove the floating grease, garbage and fecal matter by screening or sedimentation, and discharging the effluent at a distance from shore sufficient to prevent its immediate return. In New Jersey along the seacoast an almost continuous line of summer resorts are fast becoming factors in the wealth of the state and the people of these places feel that it is essential to their progress that the bathing beaches be free of garbage or offal.

Where the shore is of such a character as to be unfit for bathing it will only be necessary to prevent local nuisances and this may generally be accomplished by discharging the sewage in a few fathoms of water, several hundred feet from shore.

While the disposal of sewage into the ocean necessitates only a rudimentary purification, there are certain aspects of the construction that require very careful consideration. The discharge point of the outlet should be at all times submerged and a considerable distance from the shore, in order to prevent nuisances caused by bad odors and unsightliness. The distance to which the outfall is carried beyond low water mark will depend upon the configuration of the sea bottom, the currents of the water and the direction of prevailing winds. The outfall should be laid on the bottom of the sea and weighted so as to prevent its movement by waves and currents. It should leave the shore below the low water mark, otherwise the constant washing of pebbles and sand against the pipe will cause it to be worn away.

We may, therefore, conclude that, where bathing is not an important asset, sewage may be satisfactorily taken care of by discharging it some distance from the shore and below the surface of the water. It will probably never happen that it would be inadvisable to carry the sewage to sea by some type of outfall. Where bathing is a valuable asset, either pecuniarily or as a matter of pleasure, it will generally be economical to remove floating solids by screens or sedimentation and discharging the effluent at sea as before. With regard to disinfection, it would not appear to be necessary now although it is conceivable that in some cases adverse currents would make it necessary.

BAYS AND SOUNDS

When we move our disposal plant to a bay or sound, unless it is an extremely large one, we find that the degree of purification demanded by the environment will be considerably better than for the ocean. For it is here that we find oyster beds, clam beds and boating in addition to the points affecting ocean disposal. The sewage is discharged into a more or less restricted volume of water, in which the oscillating tides carry sewage back and forth until the sludge of the sewage will be deposited at not a great distance from the outlet. This, of course, depends largely upon currents. The currents in the bay will ordinarily be less strong and, because of its land-locked nature, will be much more restrained as to distance than those of the ocean. But ordinarily the bay is of sufficient size to satisfactorily take care of the sewage in the same manner as the ocean, except where the sewer outlet is within striking distance of some shellfish bed, therefore, all that has been said in reference to ocean disposal may be considered as equally applicable to a bay in which no oysters are grown.

On some of these bays, because of marshes and undesirable land, the question of local nuisance may often be of little or no importance. In such a case all that would appear to be necessary is the removal of such floating matter as might drift to nearby shores. Such a condition would be a rare case. Where it is only necessary to prevent nuisances, because of valuable adjoining properties, the effect of tides, winds, currents, sand bars, and the depth at which the sewage is discharged must all be carefully considered. In most cases rough screening and sedimentation, or possibly a very fine screening, will be satisfactory, if the effluent were discharged at some considerable distance from shore and the outlet at all times submerged. An objection to screening is that a secondary nuisance is liable to be caused before the screenings are removed or buried. It may even be that for many very small places no treatment at all would be necessary. The amount of wastes being so small as to be inconsiderable.

Where oyster or clam beds are nearby or situated so that they may be affected by the sewage, the question indeed becomes more complex. The question of the several rights of oyster growers and sewage polluters is a difficult question to adjust. Often oyster men are compelled to pay to the state certain license fees for permission to use the waters for oyster growing and it may be asked whether the state at large should not protect the waters from which they collect revenue. This is a much broader question than it at first appears, for

it must not only take into consideration present conditions but the prospective value of a growing industry.

It would seem that the use of the oyster as an article of food is rapidly increasing with improved methods in the sanitary handling and shipping of them. It, therefore, must not only be a question as to the present value of the oyster crop and the cost of sewage disposal, but it must take into consideration the possible future growth of the industry. To allow unpurified sewage to discharge where osyters could be favorably grown would have a tendency to prevent future development in a business, which in some states is of several millions of dollars per annum in value and is increasing in value every year.

Possibly, it is this danger of discouraging future growth in this respect that has led to the installation of elaborate disposal plants on bays, when required by some central authority. This point can generally be satisfactorily considered for any particular locality by ascertaining whether the location is adaptable to the growth of oysters, and whether if oysters are grown, they could be readily marketed.

It is apparent then that, in some cases, the discharge of raw sewage is allowable especially where the nuisances would be of little moment and the shellfish industry of no importance, because of no ready means of marketing products.

It would further appear that, where a large urban population is resident within marketing distance of present small shellfish holdings or where future beds could be maintained, it would be well to protect the oyster beds by some form of efficient disposal. Fortunately, such a system is available at low cost in a settling tank and hypochlorite treatment. Where natural sand beds are available, it would often form a cheap method of disposal.

It must be borne in mind, however, that pollutions from navigation are always present and no satisfactory method has as yet been proposed for the control of this factor.

However, except for limited and narrow straits or channels at the more important seaports, the danger from such pollution would be very little if any greater than that from the residual bacteria in effluents from so-called sewage purification or so-called sterilization plants. This is due to the great dilution of such discharges which in the passage of the vessel are distributed over a large volume of water and any polution would generally have to be further diluted by passage to points where contamination is possible. It must also be borne in mind that nature is, of itself, capable of taking care of a limited number of bacteria.

RIVERS AND SMALL STREAMS

The whole aspect of sewage disposal, however, changes when we come to rivers and smaller streams. With the rivers, the question becomes much more involved, as here we begin to approach the question of the protection of water supplies.

Where the rivers are large and of a tidal character all that has been previously stated in reference to bays may be considered as applicable. When the river is not of a tidal character it is very liable to be used as a source of water supply, and this fact must be taken into consideration in determining upon the necessary degree of purification.

Formerly it was thought that the problem of the disposal of sewage in rivers was satisfactorily answered by conforming to any of the various conflicting laws of dilution, the burden being thrown upon the purifying action of the stream. These laws, in the light of a more advanced sanitary science, have fallen into more or less disrepute. They appeared to be directed more particularly to the prevention of nuisances, and while, at present, this question is still of importance the bacterial standpoint is fast becoming the primary standard. We are not so much interested as to whether there is a danger of bad odors arising from a discharge into streams, but as to the effect of discharging pathogenic bacteria into the water. Where will they go? What increased danger to health is there from them? These are the questions in which we are today interested, rather than, will it smell? will it be unsightly?

There is no doubt that the laws of dilution may advantageously be followed in some cases. More particularly in the cases of small or medium sized towns situated upon the banks of large rivers, in which tributaries or other sources of water supply are available besides the river itself. There are, nevertheless, several points which even in a system of dilution necessitate careful consideration. A very important one is the manner in which the discharge is made. A sewer discharging at the shore line or into a large eddy will not readily be diffused by the river waters to the extent that it should. In fact, the discharge may so be made as to cause unnecessary nuisances along the shore line. Mud banks may be formed which in a low stage of the river will become malodorous, or at times of flood will be carried down stream, making the water worse than it ordinarily would be.

In the more populous districts of the east it often happens that a city, having outgrown its water supply, finds all other smaller streams controlled by neighboring and smaller municipalities and the main

body of the stream so polluted as to be useless for potable purposes. They are then compelled to go long distances at great expense to obtain waters, which if the main body of the stream had been fairly well protected a supply would have been found at their very door. This supply, of course, would have to be filtered, but even at that, there would often be a considerable saving of money.

There is one other effect of any process of disposal by dilution which it is well to consider and that is upon the inhabitants along the stream. They feel that the river is a common catchall and as a result there are innumerable private sewers discharging into or near the river, factories turn in dyes and wastes in any manner at all, floating offal and garbage are thrown in, ash-heaps appear along the banks. Consequently, real estate along the river, which should generally be the most pleasant and valuable place for residence, is given up to tumble down buildings.

It might be that the assimilative ability of a river could be apportioned among the various towns and cities and municipalities situated upon its banks. Just simply because a stream has the power of assimilating the sewage of a city is not necessarily a reason for disposing of the sewage by dilution. There may be other municipalities farther up or down the stream and they should have an equitable right of disposal by dilution. This apportionment could be made upon the ability of the river to oxidize the solid matter in sewage. A possible method of making the apportionment would be for a board or commission to award to each municipality in the watershed the privilege of discharging a certain amount of unpurified sewage into the stream. The ratio of the amount might be made upon the basis of area with the population entering as a factor. Then, each city, town, village or hamlet would have the privilege of contributing a portion of sewage such that at the next town the river, slightly impaired but still of a stable nature, would be capable of receiving an aliquot portion of that town sewage, and so on down the river.

Then when the sewage of any municipality has grown to such an extent that it has reached an amount greater than its apportioned flow, they might buy additional rights from other municipalities or purify the surplus.

Such a process would not make drinking water of a river and would be very liable to make the river of such a character that even after purification people would not care to drink it. Possibly many of you have seen purified sewage that looked good enough to drink, but you would not care to drink it.

Further, this plan is necessarily an idealistic one, as the oxidizing power of a river is an uncertain and everchanging factor and would therefore be difficult to determine. Also the basis of making the apportionment, whether by frontage, by population, or by a combination of these two, would be a debatable question. It would, therefore, appear impossible to inaugurate such a system at the present time.

Furthermore, we must not only take into consideration present needs but we must carefully weigh the needs of the future. There are only two sources of water supply, that above ground and one below ground. The latter in many cases being absent as far as a municipal supply of water is concerned. Therefore, one of the greatest aims should be that of conserving the sources of water supply. Both are liable to pollution. The point is, however, to conserve it at the minimum cost.

In any populated watershed there is always a certain degree of pollution, which may be called natural pollution, composed of drainage from farm land, washings from bridges, roads, etc. It is practically impossible to prevent such pollution because of its large volume. It would necessitate the construction of large and expensive disposal works as well as a costly collecting system which would be in use for only a few days a year.

Any populated watershed must, therefore, be considered as having potential possibilities of a direct and dangerous pollution, as has been well illustrated in several notable epidemics. It is possible that, with an increasing density of population, it will become necessary in some cases to purify city storm water to some extent. It would, therefore, seem that any municipality deriving its water supply from a populous watershed, even though a very careful system of patrolling and inspection is employed, is morally obliged to filter the water before supplying it to consumers.

It is generally considered that storm water, from a bacterial standpoint, is as bad as sewage itself but generally speaking, it does not appear to have caused such disastrous results. It certainly is not considered in the popular mind as dangerous as is sewage. In a great measure this is, probably, due to the fact that we would expect human disease organisms to occur less frequently in the storm water. It may be for this reason that unfiltered water supplies receiving storm water from populous areas do not cause as much trouble as would one receiving the same quantity of sewage. It is also possible where a stream is polluted by storm water only, to by-pass the first and consequently worst portion of storm water and not use it in the water supply. There-

fore, by simply having sufficient storage capacity a water supply, receiving storm water at times, may be maintained in a poor yet effective manner. The same will not be true where a sewer disgorges its daily quota of disease bearing bacteria.

When we come to apply in this case any test, such as the "greatest good to the greatest number," there are several objections. For, while it may be the only true economic measure of the device, it loses sight of the stricter questions of justice and is liable to approach that of "might makes right." It would not, in this cases, take into consideration the several rights and privileges of riparian owners and loses sight of the old common law which gives one riparian owner the right to receive the waters of a stream in as good condition as the persons above him. The answer might be made, that damages could be paid to all persons whose rights were impaired, but if all the riparian owners were paid and the damages could be ascertained in a reasonable manner, which is impossible, the economy of disposing of sewage in a raw state would be very doubtful.

Some claim that it would be cheaper to allow the water purification system, which should be installed in most cases, to take care of the additional burden caused by the sewage. It is difficult to see why the burden should be shifted from the disposal plant to the water filter. The only place in which such a procedure would be permissible is where the quantity of sewage to be purified would cost considerably more than to purify a comparatively smaller amount of water. While this would be strictly an economical arrangement, there are several things that would argue against such a procedure.

The chief objection is this, that water purification plants are not perfect. They will at times fail to satisfactorily purify the water, especially with filters of the pressure and mechanical types.

This has, in some cases, caused very serious epidemics, and would mean that the municipality using the water must take additional chances of infection from a polluted source of supply and must, in addition, go to extra expense to make the water purification plant as nearly perfect as is possible. For very slight irregularities in the operation of such a plant would have very disastrous consequences.

Another aspect of the situation would be that any municipality discharging sewage into a stream would care very little what damage they caused in other municipalities. It would consequently be difficult for any municipality lower down to recover damages and they would probably be compelled to spend as much in court as they would obtain in damages and the net result would be little or nothing.

Where there was more than one municipality polluting the waters above the town purifying its water supply, the relative liability of each would be practically indeterminate.

This would mean then that the sins of one community would cause trouble and tribulation to visit its neighbor.

To digress for a moment; in constructing steel bridges or buildings we determine the strength of the steel and then take about one-fourth of that figure as a basis for safe design. So that, practically speaking, most steel structures are four times stronger than is absolutely necessary. This is done for the sake of safety. It isn't considered good policy to work the steel to a point near its ultimate limit.

But those people advocating that water purification should take care of sewage pollution would seem desirous of working the former to its ultimate limit. The failure of the "schmutzdecke," the entrance of wash water into the clear water, a failure in the supply of alum, soda, or hypochlorite, and the barriers are down. Would it not be better to relieve the burden of the water purification plant as much as possible and wherever possible destroy the pathogenic bacteria in sewage? Would it do any harm to have a factor of safety of two and purify both the sewage and water? Then, in the event of the failure of one, the consequent results would not be so bad as though all the burden were placed on one installation.

The waters of a state should be available for a water supply in as unpolluted a condition as possible, no matter whether the population is urban or rural.

With respect to rivers then, we may conclude that the degree of purification of sewage should be such as to maintain the river in as nearly an unpolluted manner as is possible when the several uncontrollable factors are taken into consideration. These uncontrollable factors, in the case of a stream necessary for a water supply, should be eliminated as much as possible. In this connection, it may be said that it is altogether probable that, in future years, with heavier populations along the smaller rivers, it will become necessary to control the discharge of storm water. It is regrettable that there is not, at present, more definite information as to the degree of pollution from a pathogenic standpoint when storm water, from a separate sewer system, is discharged into streams.

We may, therefore, conclude that where the river could be used as a water supply any of the methods of purification which would prevent nuisances and greatly reduce the number of pathogenic bacteria would be a satisfactory means of disposing of sewage. This might

mean simply the settling and sterilization of the sewage or its purification after settling on sprinkling filters and disinfection. The latter method would, however, only be necessary where the amount of sewage discharged is large in proportion to the flow of the river.

On smaller streams and lakes the same arguments will hold with the exception that dangers of local nuisances are much augmented by the smaller quantity of water in the stream. Complete disposal plants will, therefore, be more often installed on small streams than at any other place.

It will be noted that the process of disinfection by hypochlorite of lime occupies a rather prominent position in the proposed methods of sewage disposal. This process, while under a slight cloud of suspicion as to its effect upon some of the more resistant bacteria, appears in actual practice to remove such a large percentage of pathogenic bacteria as to be an effective means of disposal.

There are several processes of disinfection by electrical methods that might satisfy the conditions, but until they have been thoroughly tried out and the result measured, according to the present and approved methods of analyzing sewage, they must be treated with suspicion. They are also generally considered as more expensive than the simple treatment by bleaching powder.

CONCLUSIONS

In view of the foregoing statements, the following conclusions would appear justifiable:

Where sewage is discharged into the ocean, the question will rest upon the value of the bathing privileges and the health and comfort of the residents along the beach. Where the latter consideration only is of importance the disposal of sewage by discharging it below the water surface, several hundred feet from shore, will be satisfactory. If the former is of considerable value it will be desirable to remove floating solids and grease by sedimentation or by passing the sewage through fine screens.

On bays, where there will be no danger to shellfish, unpurified sewage may often be disposed of in a raw state, unless bathing, freedom from nuisances, or boating is of such importance as to demand the installation of settling tanks or screening devices. If the bays are used for shellfish the sewage should be disinfected by some adequate process.

On rivers the same conclusions may be drawn in general. If the

rivers are small and the quantity of sewage comparatively large it may be necessary to remove suspended matter by some process of filtration and disinfection of the effluent.

It would not appear to be equitable to allow the discharge of raw sewage into a river as it tends to increase the burden of other municipalities with very little opportunity for proper adjustment of damages.

As to the smaller streams and lakes the disposal plants will usually have to be more complete, because of the danger of putrefaction in the stream in addition to the above consideration. This will in general mean the installation of settling tanks of some kind and secondary treatment on sprinkling filters, double contact beds, or sand filters. The degree of purity will, in general, depend upon the amount of water in the stream and disinfection would only be necessary where the sewage would enter a water supply or where it could affect shellfish.

DISCUSSION

Mr. Chester G. Wigley: The speaker would like to say that this matter has been before the sanitary engineers of the country for the last few years and is getting more important every day. Up to the present time there does not seem to have been any decided action taken leading toward a general policy that state boards of health may follow in passing upon plans for sewage disposal. It may be that the engineers are simply devoting their time in preparation, or it may be that practicing engineers feel that no matter what conclusions they might come to the same would not be satisfactory to a certain part of their clients, and for that reason they are holding back because it might affect their reputation with some of the people.

As the speaker has no particular reputation at stake he has taken this matter up, and hopes that it will meet with a full discussion, because the subject is so big that it is almost impossible for any one man to handle it. There are so many factors that come up for consideration, that the only way they can be completely considered is through a great many people discussing them.

President Gwinn: The speaker was very much impressed with one fact brought out, that is that the people are entitled to the water from the streams in a fairly good condition. He thinks that is true, that the burden of purifying the water should not depend entirely upon the water department, that the people should take care of the impurities that are put into the streams and that the discharge from

sewerage plants should be reasonably innocuous before it is allowed to flow into the streams.

Mr. F. B. Leopold: The proposition of giving a factor of safety of two instead of one is of course one that should be heartily endorsed by everybody. In other words, the better water you have to supply to a water purification plant the more of a factor of safety you have in the operation of that plant; and while there is no question but that the sewage can be taken care of in a water purification plant with careful and proper operation, yet the chances of something going wrong are always there, and the greater the number of chances that can be eliminated as to improper results or carelessness in operation, the greater is the insurance on the results that are going to be delivered to the community; and for that reason everybody interested in water purification should heartily endorse any proposition that will lead to the best type of water being delivered to a purification plant for purification, because the best type that we will get normally is not the character of water that is fit for consumption.

Mr. M. N. Baker: The main thing that the speaker wishes to get on the record is, that this question has to be looked at in a very broad way.

Some of our state boards of health approach the sewage disposal problem of a municipality as if that were the only object of expenditure before the municipality, and they insist many times upon almost perfection.

This narrow way is partly due to the fact that with the limited appropriations available for our state boards and departments of health they are not able to have that full knowledge of the sanitary and health protective needs of each community that they ought to have when they are called upon to pass judgment upon one of those needs.

If every state board of health when it was called upon to pass on plans for sewage disposal had a full knowledge of the health conditions in the city concerned, what it was doing for its water supply, what it was doing for its milk supply, and so on through all the list of things that vitally affect the public health, they would often handle this sewage disposal problem very differently from what they do.

There is a limit to the possible expenditure that any one of our cities can make. You can go just about so far with bonded indebtedness and just about so far with the tax rate, and then you have to stop

for you run up against a constitutional limitation of indebtedness, or a constitutional or legislative limit of taxation. Certainly when you try to sell bonds you find that the bond houses have something to say, and your bonds go at a low figure.

All these things must be taken into account, the other health protective means of the municipality, and the financial resources of the municipality.

Then there is an underlying assumption in the paper that has been read here that it is simply a matter of going as far as you choose in the bacterial purification of sewage. The speaker does not deny the possibility of high bacterial purification, if no limit is placed on the cost, but it has been only recently that we could expect to do very much in that direction. But remember this, that throughout the whole world today there is scarcely a sewage purification plant of any size that is being operated for bacterial reduction.

When you talk about purifying sewage so as to take the burden off the water supply, you are likely to mislead the general public. They will think that because some sort of sewage purification plant has been put in, no matter what it is, nor how it is operated, that the burden has been taken off the water supply, and that there is no longer any danger from that source even if the water is not purified.

A great deal more might be said. Perhaps the speaker has said too much in view of all there is yet to be presented here.

Mr. Alexander Potter (by letter): The writer has read with interest Mr. Wigley's paper, and fully concurs in his general conclusions. It is to be hoped that his paper will be read by the state health authorities throughout the country, for the writer is not averse to saying that education along proper and rational sanitary lines is needed by some our of state health officials. He makes this statement notwithstanding the fact that in some of the states in the Union the state health authorities are lending every effort to the intelligent advancement of proper and rational sewage disposal.

The problem of sewage disposal, excepting where the discharge is directly into the ocean, is one in which the cities below are very much more vitally concerned than the city whose sewage disposal problem is under consideration. The sooner this view of the situation is conceded, the more rapid the progress that will be made towards a proper solution of this problem, and the greater the harmony between the various cities of the states and nation.

When a city is asked to spend large sums of money to purify its

sewage, no amount of argument can make the average citizen believe that his city will directly receive an adequate return for the money they are thus called upon to expend. On the other hand, when the relation between the municipality fouling the river and the city below depending upon that stream as a source of water supply or for some other legitimate purpose, is clearly realized and the obligation of the city polluting the river forced home to them, there is every reason to believe that the problem of sewage disposal in its proper light will be taken up and advanced by all the cities throughout the country. Then it will be that city lines will be abolished so far as this problem is concerned, and all will work in harmony for the common good.

That the questions of sewage disposal and water supply are intimately correlated, cannot be gainsaid; neither can it be well disputed that in a vast majority of cases, the benefits to be derived from a sewage disposal system are appreciated and are of greater interest and benefit to others than to the city actually considering the question of sewage disposal. And, therefore, when any city is asked to go to a considerable expense for the benefit of its neighbor, the question naturally arises, can the neighboring community or municipality secure relief from the pollution of its water or the fouling of the stream by its upstream neighbors in some manner more economical and effective than by the purification of its neighbor's sewage to a relatively high degree of purity?

In the majority of cases where a city receives its water supply from surface streams, purification of that water supply is essential. Therefore, the character of the sewage disposal plant necessary for any town must be considered on the basis that the town below in any event is or should be purifying its water supply. With this assumption, we are able to recommend a simpler method of sewage disposal for the town above than otherwise would be possible or practical and thus are more likely to secure action upon the question by this town. The expense of purifying the sewage of any town to such a degree as to prevent pollution from that town affecting the water supply of the town below which is without a filtration plant, would be prohibitive in the vast majority of cases throughout the United States. Because those in authority in some states hold these views, rational and beneficial improvements are postponed.

It is essential that we first reach some common sense conclusion as to the amount of purification to be effected in the sewage of a particular city, for until such a conclusion is reached upon this point, it is impossible to determine even approximately the financial obliga-

tion on the part of any town when they undertake the purification of their sewage. Under certain aspects this problem may involve the complete reconstruction, not only of the city sewers, but also of the house connections leading from the sewers to the houses, and also the reconstruction of the house plumbing in many cases. And all this notwithstanding the fact that at the time these sewers were originally constructed, the advice of the ablest engineers in the country was sought and followed.

While it is true that there are sewers throughout the United States which have been improperly designed and badly constructed, it is not true in the vast majority of cases, and it is therefore somewhat of a reflection upon the engineering profession as a whole if at this late day cities are asked to abandon the use of sewers which for years have been assumed to be well designed and well constructed, when our knowledge of the effect of sewage discharged into large bodies of water is not changed one iota.

In conclusion, the writer is of the opinion that the problem of sewage disposal to be solved is to maintain a proper relation between the amount of sewage, crude or treated, that is to be discharged into a body of water and the ability of that body of water to absorb the sewage effluent. The method of sewage disposal which can in each case economically perform the required service at any city is the one that should be adopted. No one method is applicable to every case.

It is to be hoped that as time goes on, there will be a more rational view, first, as to what sewage is, and second, as to its proper method of disposal. The average citizen of any town is either indifferent to the whole subject, or is apt to be led astray by the popular fallacies upon the subject of sewage and its proper disposal.

PHENOMENAL GROWTH OF THE WATER WORKS OF EDMONTON, ALBERTA

By A. Maclean

It is practically impossible to give in detail all the trials and tribulations which we were called upon to bear. The writer, therefore, can do no better than give a short synopsis of the phenomenal growth which the city of Edmonton has enjoyed, and still continues to enjoy, from which he thinks you can deduct your own conclusions, as to what the officials were called upon to contend with.

It is not the intention of the writer to give a lengthy essay on this subject, but, as stated above, a short synopsis showing that a superintendent growing up with a growing city, such as Edmonton, has not always a bed of roses to lie upon.

Before going on with any statistics with reference to the growth of the water works department of this city, it may be well to give, for the benefit of those members who do not know, a few paragraphs outlining just what and where Edmonton is.

Edmonton, the most northerly city in Canada, being the capital of the province of Alberta, is situated in that province some 400 miles north of the 49th parallel, or international boundary. The city occupies a picturesque situation on the high banks which overlook the valley of the Saskatchewan. It is located some 200 feet above the river, from which it draws its water supply.

The city covers an area of some 35 square miles and boasts of a population of between 40,000 and 50,000 people, as compared with between 2000 and 3000 in 1901.

The records of activities in the building trades will go to show that she is not behind in this matter. Permits issued during the year 1911, $3,672,260 as against $2,159,106 in 1910, $2,128,166 in 1909, and $1,086,864 in 1908. So far this year building permits amount to $4,699,092.

So much for the general statistics with reference to Edmonton, let us now refer to its water question, which as you all know, is the most vital question which a rapidly growing city has to contend with.

Edmonton, as stated before, being situated some 200 feet above the river from which it draws its supply, is naturally forced to pump its

requirements. The river also, on account of its muddy condition during freshet periods, necessitates the city depending upon a process of filtration for the clarity of its supply.

The first installation of water works in Edmonton was made in 1901 and 1902. The water was turned on in 1903 and was controlled by a duplex pump with a rated capacity of 750,000 gallons per twenty-four hours, which supplied 103 services. About two years later another pump was installed, with a rated capacity of 1,500,000 gallons per twenty-four hours.

These two pumps were arranged for two-stage pumping, due to being too high above river level to permit them from drawing direct by suction. Two motor driven, vertical, centrifugal pumps were then located in deep wells in the same building as the above mentioned pumps, which drew the water from the river, and discharged it into a basin outside the building, on the same level as the first pumps, from which they drew their supply.

In 1907, the city decided to increase their pumping capacity on account of the demands they were then called upon to supply. They, therefore, installed a 3,000,000 gallon turbine pump direct connected to a motor. This increase in their pumping capacity within a year or so was found not to be capable of meeting the demands, therefore, in 1909 a 6,000,000 gallon high duty, vertical, triple expansion pump was installed. These last mentioned pumps then were capable of supplying the demands of the city, but about the end of the year 1910 it was found necessary to install another pump, capable of delivering between 6,000,000 and 8,000,000 gallons for twenty-four hours. The city then ordered a centrifugal pump direct connected to be installed.

In 1907 the writer suggested to the city council the installation of a filter system. Considerable discussion took place in the council at the time, and it was some two years before the suggestion was put into force. In 1909 an order was placed for the installation of a 4,000,000-gallon filter plant, which was installed and put into operation in 1910. In 1911 it became apparent that the filter system then installed would not carry out the work required, therefore, an order was given for four additional filter units making an increased capacity of 2,000,000 gallons, which are now installed and in operation.

In 1908 the writer suggested to the city council that the present site of the pumping plant was not in a proper location owing to the growth of the city, and that it should be moved beyond the zone of

contamination. This report or suggestion is now being carried out, and it is the intention of the city to move its pumping plant some few miles up the river, and install there a complete plant, including filters, etc.

To give some idea to the members of this association as to the rapid growth of the water works department of the city of Edmonton, the writer gives below some figures and statistics which he thinks will be self-explanatory.

Comparative statement showing growth of water works department, from 1903 to 1911 inclusive

YEAR	REVENUE	SERVICES
1903 (6 months)	2,116.32	103
1904	13,145.96	223
1905	23,414.53	405
1906	37,498.19	857
1907	55,444.16	1925
1908 (11 months)	49,633.67	2520
1909	59,734.96	3123
1910	76,167.96	3824
1911	117,768.89	4736

At the end of the year 1911, there was installed in the city 79.90 miles of water-mains. It is the intention of the city this year, owing to the rapid growth, to install some 25 to 30 miles of additional pipe line.

To give some idea as to the cost of operation of the system in Edmonton, the writer gives below a few statistics which will speak for themselves:

Total cost of maintenance to mains for year	$2,120.98
Average cost of maintenance to mains for year per mile of distribution	34.94
Average number of breaks per mile of distribution	1.16
Total cost of maintenance to services for year	3,042.56
Average cost of maintenance per services in system	.64

As it was the intention of the writer to only give a short essay on the development of the most northern city in Canada, he thinks it is proper that at this point he should draw a line and stop, as he believes from the statistics that have been given, the members of this association can realize that the heads of the different departments operating in the city of Edmonton have no small contract on their hands.

DISCUSSION

MR. A. A. REIMER: How deep do you have to lay your mains?

MR. A. MACLEAN: They are covered 8 feet to the top of the pipe. Last year we averaged with our electric thawing machines ten or twenty thaws per day on the services, every one of them inside of the street line. We use both lead and iron services; lead up to 1-inch, from 1-inch to 2-inch, galvanized iron. We are metering every service in the town.

MR. A. A. REIMER: Did you say that the frost went down 8 feet?

MR. A. MACLEAN: The frost went down 7 feet 6 inches. We had to thaw services out with an electric thawing machine.

PRESIDENT GWINN: Is that the way you celebrate the Fourth of July up there?

MR. A. MACLEAN: I will tell you, I have thawed services out there in July.

MR. JOHN M. DIVEN: There are one or two points which Mr. Maclean did not touch on. It is a comparatively easy matter to put in additional pumps when increased consumption demands them, but it is different with an outgrown distribution system. Did you have to renew portions of the distribution system; take up pipes to lay larger ones, or parallel distribution pipes?

MR. A. MACLEAN: Do you mean on the piping system? Well, just about three or four weeks before leaving home we duplicated a 20-inch line from the pumping station, and made a connection to the other pipe of the main system leading to the city. We are now continuing that main into the city. Mr. Potter gave us a report on that and we have been following out this system. We have lines laid out for 36-inch and 40-inch lines now.

MR. V. A. THOMPSON: Is the soil of such a character that you can use a ditching machine?

MR. A. MACLEAN: We have a number of ditching machines. The old system in Edmonton was a street system; that is, the water and

sewer pipes were laid in the streets. Today the water mains and sewer mains are laid in the lanes, or alleys, as you call them here. These lanes are only 20 feet wide. In these lanes there will be electric pole lines, etc., therefore, a ditching machine has no room to work.

Mr. V. A. Thompson: Do you lay water and gas pipes in a tunnel, or in the soil?

Mr. A. Maclean: Just in open trenches. Some one asked what the character of the soil was? It is a clay soil that looks all right. You who live here would never think for one minute that a trench in that soil would cave in; but in ten minutes the whole side will go in.

Mr. F. J. Connor: Do you put down pavement over the galvanized services, and what kind of pavement?

Mr. A. Maclean: We have a number of different kinds, bitulithic, wood block, granitoid, different pavements. Before paving a street every lot was formerly provided with a service. From an economical standpoint the speaker figured that it was not to the benefit of the city or any saving to the city to install those services, because owing to the number of services that were called for along those streets during the year it would be cheaper to put the paving in and install the services afterward. Therefore we do not now install the services before paving.

Mr. F. J. Connor: We are up against that proposition at Sioux Falls at this time. The city took over a new plant and have had it in operation about five years. Previous to that all the services were galvanized iron; we are still putting in galvanized services. Our people have now a paving craze and they are paving block after block; the water department is not ready for paving. We have to put manholes over our valves, and all the vacant property between the services want services run in before the pavement is laid. The question is whether it is wise for us to put down paving over galvanized services or take all the galvanized iron services up and renew them with lead? Personally the speaker would advise putting in lead services; but the question is whether we can get the street ready to take care of the clamor that is rising for paving. We have a lot of granite paving in the down town district; we have been quite successful in relaying this on a sand base and concrete filler. Now they want to

relay a lot of that granite block in the business district, and fill it with concrete filler. We have some of the old galvanized services under that pavement. Of course we could renew them, but the question is whether it is good business policy to do so. The speaker wants to know if other water works men agree with him about putting in lead services. He knows they are long-lived whereas galvanized services are not; but it is a hard proposition to take up all those galvanized services which have been installed in the last five years. What has been the experience of others in repairing galvanized services under a concrete pavement?

Mr. A. Maclean: On the main street in Edmonton this spring we have replaced in one block eighteen galvanized iron services, and we have not yet replaced one lead service. The speaker examined the question, thoroughly, and got reports from a doctor in Montreal which confirmed his suspicions of electrolysis. He will say that the electrolysis did not affect the lead the same as it did the galvanized iron. The only reason that he did not use lead pipe for 1-inch to 2-inch services is the cost of the pipe; that is the only reason.

Mr. V. A. Thompson: Regarding the electrolysis, the speaker would not advise anybody to try to protect themselves from electrolysis by using lead pipe. We have had trouble in Phoenix, Arizona, from electrolysis and have also been up against the same proposition as to paving as the last speaker; and our practice has been to use galvanized iron pipe, that is what we class as pure iron pipe—whether it is or not we do not know—but at any rate under all street railway electric lines when putting in new or renewing old services we use electric conduit and insulate our pipe thoroughly, and figure on getting some protection in that way.

We have not adopted the practice of putting lead pipe in services. We use galvanized iron for all services under the pavement. On vacant property, where property owners do not wish to install service we do not compel them to, but the property owner may do so if he sees fit to pay for the service before the pavement is laid. With old services we do not require the property owner to pay for renewals.

Mr. F. J. Connor: Our city had to run the services from the main to the curb in order to take the consumer away from the old company. The consumer said to the water department, "If you want us to use the city water you will have to give us services." If we renew those

services with lead pipe it means additional cost to the city unless we can pass an ordinance adding the cost to the rate. The speaker has investigated quietly with regard to lead lined pipe and would ike to hear some experiences with lead lined pipe. Of course the agent selling it will tell you it is the best on earth, but the men who have used it know what it will do, and the speaker would like to have some of them tell what they know about lead lined pipe, what their experience with it has been.

Mr. R. L. Clemmitt: The speaker supposes the city of Baltimore is the largest user of lead lined iron pipe in the United States. We began the use of it for service pipes in 1897 and have continued its use ever since. The speaker can not see how we can expect this pipe to be more durable in service than a good galvanized pipe as the outer surface has no more protection from the chemical action of the soil. The lead lining will withstand the attacks of any chemicals which are likely to be found in a city's water supply, and makes a very clean service pipe.

The first lead lined pipe that we used was simply a black iron pipe with a thin lead lining which could be easily pulled out, leaving the pipe no better than an ordinary black iron pipe. This product, however, has of late years been greatly improved as the manufacturers have found a way to amalgamate the lead with the iron so that the two are as one solid metal, and the pipe can be cut, threaded and fitted like ordinary wrought iron pipe. The outside of the pipe is now treated so as to resist the action of soils better than formerly.

At one time we had considerable trouble from electrolysis on service pipes in the vicinity of the power houses of the United Railways and Electric Company, but can not say that lead lined pipe was affected more than any other kind would have been. Those that were affected were of the old style pipe that the speaker referred to.

In regard to protecting service pipes the speaker has noticed for some years that our gas company wraps their service pipes with several layers of burlap thoroughly saturated with gas tar. Just what is accomplished by this wrapping, he is not prepared to say at this time, but if any one here is interested and will write him he will take the matter up with the gas company and furnish full information as to their experience with this method.

Mr. W. F. Wilcox: At Jackson, Mississippi, there were a great many vacant lots and before paving they put in a number of lead

services for the prospective consumers. The speaker would like to ask Mr. Fewell's experience with them.

Mr. J. H. Fewell: In Jackson, Mississippi, we have a great number of lead service pipes that were put in fourteen years ago, when some of our streets were paved, that have given excellent service, and no failures have been noted. When the paving was done service pipes were put in for all prospective consumers, some of which was then vacant property, these services have been connected to from time to time and all found in perfect condition.

When we put down paving on any of our streets we tap the main and run a lead service pipe from the main to the curb, provided with a curb stop and box ready for use, for each abutting lot, which prevents the necessity of breaking into the paving to tap the main as the property is occupied and water required.

No lead lined pipe has been used in our city.

Mr. A. Maclean: Our ordinance provides that for anything over and above $\frac{3}{4}$-inch the consumer must pay for the difference in cost between the lead and galvanized iron.

Mr. V. A. Thompson: We have taken a great deal of care to prevent electrolysis in our service lines. The speaker has taken up the matter and is trying to get some action on the part of the street railroad company. The city council seemed to think that if he would use lead pipe he would get rid of the trouble from electrolysis. It was therefore necessary for him to resort to lead pipe services in the street railway district in order to see whether that would improve matters, and to get the matter into such shape that he could get the city council to take some action on it. We have put in a number of lead services and a number of galvanized iron services. We find that electrolysis will destroy the lead in about half the time that it will the galvanized iron pipe.

Mr. E. H. Breidenbach: What kind of insulating material did you use over your services to prevent electrolysis?

Mr. V. A. Thompson: We use a fiber conduit, such as is used in electric lighting conduits where they run an electric cable underground. We do not use anything smaller than a $2\frac{1}{2}$-inch conduit, and we use that for all sizes of pipe that will go through it. We also use 3-inch

conduit for larger pipe. We cement the joints together with cement furnished by the makers of the conduit, and close up the ends of the conduit with cement on both ends.

PRESIDENT GWINN: One railway company suggested that the water company enclose its water pipes in glass, have a continuous glass pipe outside of the water pipe, that that would insulate them so that there would be no danger. The manager of a company in our city suggested that we take the pipes out of the ground altogether. In the meantime he is using our pipes to return some of his current to the dynamo.

MR. W. F. MONFORT: The speaker desires to call to the mind of those present one very good point that was made last evening as to the character of the soil and the moisture in the soil in the outlying country where our frozen friends come from, where there is such a light rainfall, and the soil is constantly highly alkaline because it never has had a chance to get washed out since the Almighty put it down there. That it seems to me would present ideal conditions for the development of electrolysis, which our Sioux Falls friend has in a lesser degree because he gets a little more rainfall, although he has not lost all his alkali yet. These two cases of electrolysis very nicely point the moral of last night's address.

MR. V. A. THOMPSON: The speaker takes exceptions to the alkali, because our soil is not strong in alkali at all.

MR. W. F. MONFORT: What are the salts in the soil there? You must have something else in there if not alkalies. What is the alkalinity of your water?

MR. V. A. THOMPSON: I could not give you that offhand.

MR. F. J. CONNOR: The speaker also objects to the alkali. We think we have pretty good soil and we raise some good things on it. We have good water, and there is no alkali until we get west of the Missouri River in South Dakota where you may encounter alkali, but at Sioux Falls very little alkali develops in the soil.

MR. W. F. MONFORT: I think the gentleman has taken exceptions to my remarks without going into the question. There is absolutely

no neutral soil, it is all either alkali or acid. If they are not alkaline soils they are acid soils, and that is worse yet.

Mr. V. A. Thompson: We may have alkaline soils; but, in the Salt River Valley we have some 300,000 acres of the most productive soil in the United States, which runs all the way to $2000 an acre in value. We have lots of land that cannot be bought for less than $150 or $200 an acre. So it must be worth something.

Mr. W. F. Monfort: An alkaline soil is not necessarily arid. The speaker is quite sure that the work that has been done by government experts recently in their investigations regarding the conductivity of soils is very valuable and will throw much light on the nature of electrolysis as affecting underground structures. He cannot see any better opening for explaining the electrolysis of which the gentleman complains than is presented by such investigations. It is not necessary that the soil contain sodium sulphate or sodium carbonate in order to produce conditions favoring electrolysis. We get a great deal of water from the Missouri River, and the difference between the Missouri River and the Mississippi is decidedly marked as regards the amount of sodium salts in general contained in it. Of course the matter dissolved in it comes from the soil of not only the arid plains west of the river, but it gets a considerable proportion of calcium and magnesia out of soil that is derived from the glacial drift that covers the area of the valley of the Missouri; so that the waters coming from that glacial drift would have what we call chemically speaking high alkalinity.

Mr. E. E. Davis: In regard to the requirements as to services in our city the speaker will state that we use all lead up to 2-inch, and over that size cast iron. In regard to the street, when we put on block asphalt or bitulithic we put a connection into everybody's lot, and the lot owner when he builds on the property pays the city back the cost of the lead pipe from the fence out to the main. We require all lead connections. The speaker could take you just across the river there and show you a piece of galvanized iron put in fifteen years ago which is all eaten up. As a general thing down there the soil is good and the lead pipe lasts for years and years. Where there is a connection liable to be destroyed we put about four inches of sand all around the pipe, and then we do not have any trouble from the action of the soil. The electrolysis down there is a peculiar thing;

we have had more trouble with it than anybody on earth. We had the first electric railroad that was ever built in the world, in our city of Richmond, Virginia. It was a long time before they could find a way to run an electric car around a curve and also to get a car that would not jump the track. Mr. Dabney H. Maury came down there and made a survey and report for us, several years ago. The city of Richmond had an ordinance that electrolysis must be kept from damaging water mains, and also providing that in the event that electrolysis should take place and produce any serious damage the street railway company would be required to put in either a double overhead trolley or an underground trolley. Several years ago the speaker was talking with Mr. Waterman and another bright man on the subject of electrolytic action, and he said, "Gentlemen, will the double overhead trolley prevent electrolysis?" Mr. Waterman says, "Yes." Another gentleman said, "No." The speaker said, "How about the underground?" He says, "That is pretty good, but that would not entirely eliminate it." The speaker said, "Will you tell me what will entirely eliminate electrolysis from a water main?" One gentleman said, "Mules." We have had a lot of trouble down our way with electrolysis, or at least we used to, but it is not nearly so bad now. Sometimes when our men find a pipe damaged by electrolysis the speaker has to go and look at it for he finds he has to go himself to tell the engineer of the street railway company whether it is electrolytic or earth action. He never saw a piece of pipe that had been damaged by electrolytic action that was not smooth on the bottom.

We have had comparatively little trouble with lead pipes, because the railroad people have been kind enough not to put any more current in the pipe than they could possibly help. We send them word when any trouble is experienced, and they send down and see if the bond is broken, and they pay for their own damage. On the other side of the river, south of Richmond, the water works were built in 1887 or 1888, and they used a great deal of galvanized iron pipe for services and in some cases for mains. We took charge of those works in 1910, and are now replacing the 2-inch galvanized iron main pipes with 6-inch cast iron and the smaller services with lead, where they are entirely eaten up. The galvanized iron pipe is not much account for water in Richmond.

The speaker has never used any lead lined pipe. We have trouble in the morning with the hot water being colored, and believe this is caused by the galvanized iron pipe on account of the water cooling

at night when the fire in the range goes out and the heating of the water in the morning causes sluffing of the galvanizing and exposing of the pipe to rust, thereby causing the color. We have come to the conclusion that we had better avoid galvanized iron pipe for house connections; if we don't we will have trouble.

Mr. A. Maclean: We have a number of ordinances at Edmonton governing the water supply. One of them provides that every water service laid should be lead. Now up in our town there are a lot of people who hold property just for an investment and allow it to stand vacant. Whenever a main is laid to supply such territory we charge the lot owners 10 cents per front foot tax on every foot of vacant property.

To show you the difficulties that we are up against there and the conditions on the Saskatchewan River, the speaker had occasion to cut a 20-inch main into a 20-inch main, the old 20-inch having been laid three years. When the intersection was made he found that there was 9 inches of silt sand in the old main after three years' service.

Mr. E. E. Davis: The speaker would like to say for your benefit that the city of Richmond requires an application to be filled out and signed by a sufficient number of property owners guaranteeing that the water rent will pay 10 per cent on the cost of installation, and that if the signers of the application do not connect within four months their water bill will start anyhow whether they connect or not.

Mr. A. Maclean: Suppose the man who signs that guarantee does not come up to it?

Mr. E. E. Davis: We put the main in, and four months after that time the bill is rendered each quarter and paid.

ICE TROUBLES AT BUFFALO

By Henry L. Lyon

The city of Buffalo takes its water supply from Niagara River and Lake Erie and pumps it direct into the city mains. The source of supply is unlimited, it is only a question of being able to get it to the consumers on time. The reservoir holds 116,000,000 gallons, but is not of sufficient elevation to supply more than half the city and would not supply that part satisfactorily for more than a few hours. The daily average consumption of the city is 135,000,000 gallons and at times it runs up to 200,000,000 gallons. The reservoir on the low service and the water tower on the high service act more as balance wheels in regulating the pressure.

The old intake pier is situated about the middle of Niagara River and 1000 feet from the pumping station, which is situated on the bank of the river. The intake is built in the narrowest part of the river about 1 mile from the head of the river and the foot of Lake Erie. The current is from 7 to 15 miles per hour. The pier is connected to the suction canals, or wells, in the station by two tunnels under the river. One is 6 feet in diameter, the other, 6 by 12 feet in cross section. The ports to admit the water are about 4 feet above the bottom of the river and on both sides of the pier. The river at this point is 16 feet deep, the bottom being a smooth limestone rock, with scattered boulders. On the sides of the pier are ice shields of steel extending to 2 feet above the bottom of the river, so that the water must come under the shields and give us the water from the bottom of the river, not the surface, but on the sides of the shields are gates that can be opened and closed so we can take the surface water if ice troubles close the lower levels.

When ice is running down the river, the current turns it over and over and churns it up, forcing large quantities to the lower levels so the river is a floating mass of ice its whole depth. When the lake becomes frozen over a certain phase of our ice trouble is over for the winter and does not bother us again until the break up in the spring.

The location of the pier, however, with a swift running river for a mile above us, so it cannot freeze over, makes an ideal situation for frazil, anchor, or ground and slush ice.

Water will freeze and turn to ice if its temperature falls below 32°F.

even a fraction of a degree. The swift current prevents a surface ice forming. The frozen ice surface in the lake protects the water underneath, as the cold air will penetrate water better than ice. When water flows from under the lake ice the colder air will cause frazil and anchor ice to form. A heavy snow storm will not melt readily when it falls into the cold water but becomes water logged and forms slush.

When we speak of surface ice, anchor ice, ground ice, frazil ice, pebble ice, slush ice, or any other kind of ice, there seems to be no fixed names to separate them and in a great many cases it is impossible to tell them apart after they have changed their original position or formation and become broken up and mixed. They then become simply slush ice. The writer will try, in describing them, to take the names that seem to be the more general names given to them.

Surface ice is the form we generally see on the surface of lakes and ponds, when their surface is frozen over. It forms first on the surface, as the cold air penetrates the ice and reduces the water directly under the surface ice to a lower degree, it turns into ice, attaches to the upper ice and thus increases the thickness of the ice.

Anchor or ground ice, will only form in a running stream on a clear cold night, the air temperature being very near or below zero. It never forms under surface ice or in cloudy weather. It forms near the bottom of the river and attaches itself to rocks or other hard substances, preferably a dark substance. It loosens itself from the substance to which it is attached, when the sun rises or the weather moderates. It is very buoyant and if stones or other things are imbedded in it will raise them and float them down stream. It has been known to raise and float abandoned anchors so they could be recovered by the owner or pirates. Small boats should look out for such conditions, because at times it rises in large masses and has been known to overturn such boats.

Frazil ice is only formed in swift running streams, where surface ice cannot form and then only in very cold weather. It forms best on a dark, windy day, or a clear, cold, windy night, when the wind is blowing against the current. It is fine crystals, sometimes very hard and floats readily. When it, as well as anchor ice, is forced under surface ice and attaches to it and to its own particles, it will often fill up the whole bed of the stream and cause floods.

The anchor ice will form on the ports of our intake pier, so as to completely close them. The small particles will seem to rise out of the water, like bubbles out of champagne, and attach to the sides of

the openings, then to each other in lightning rapidity, until the whole opening is closed and cannot be broken by pike-poles. We then resort to small charges of dynamite.

Runs of ice of all the varieties, sometimes separately, more often all of them mixed into slush, get into our intake, pass down through the shafts and tunnels and then into our suction canals, or wells, in such quantities that it clogs the pumps. At times, the mixture is so solid that water will not pass through it to the pumps, and the pumps must be stopped entirely. If the ice is formed at a very low temperature, it is very hard and difficult to melt.

We have revolving screens in the canals with which we can raise large bodies of the ice above the water and then melt it with hot water and steam. We also at times will have a hundred or more men dipping the mixture on to shelves or racks in the wells, above the water, with long handled scoops, like minnow nets, but made of heavy wire, and then melting it with hot water and steam.

Niagara River for its full length (35 to 40 miles) is too swift for surface ice to form, so that anchor and frazil ice form readily. It is this ice mostly that runs over Niagara Falls in such quantities that it banks up below the falls and forms the ice bridge every winter, that becomes so solid that people walk over the river just a short distance from and in plain view of the falls. It was this same kind of ice that dammed up the mouth of the river and caused the big floods a few years ago. And the same kind of ice that has caused the floods at Montreal in the middle of winter when there had been no rains or any warm weather to melt the snow, but the floating anchor and frazil ice had been carried under the surface ice in such quantities as to completely fill the bed of the St. Lawrence River and thus formed a dam over which the whole of the Great Lakes must flow.

Our new intake pier is built at the head of the river and foot of Lake Erie in water 24 feet in depth. The current at this point is only about 2 miles per hour. The lake freezes over up to and around the pier. We believe we are in a location where anchor and frazil ice cannot form, the surface ice will only form 15 inches in thickness and our ice troubles are probably a thing of the past.

DISCUSSION

Mr. A. Maclean: After our river really freezes over we have no trouble with ice. The trouble is all from anchor ice or needle ice. We have to keep it broken up by hand.

A METHOD OF INCREASING THE DEPTH OF A LARGE WOODEN SETTLING TANK

By A. H. Meyers

The filter plant, of the water works of which the writer is superintendent, provides for sedimentation of the raw water by the use of four tanks connected in series, these tanks are 25 feet in diameter and originally were 17 feet deep with four baffles in each, the tops of the tanks being on the same level as the tops of the filter tanks.

This arrangement resulted in a loss of head of about 18 inches on the filters and made hand control necessary for both inlets and outlets, it also shortened the runs and increased the amount of wash water used.

The settling tanks, which are built of 3-inch cypress, being buried 9 feet in the ground it was not deemed possible to elevate them, so it became necessary to increase the height of the sides of the tanks. When the makers of the tanks, one of the largest tank building concerns in the east, were asked to undertake this job they refused, saying that all attempts at such work had failed. We then asked them if they would build tanks, with staves 5 feet long, around the outside of the old tanks, the new staves to project down 2 feet below the top of the old staves and to extend 3 feet above them, guaranteeing the new work not to leak in the vertical seams and to fit the outside of the old tanks tight enough to sustain the weight of the new work and of the conical roofs; this they agreed to do.

The joint between the outside edge of the top of the staves of the old tanks and the inside of the new staves we took care of by chamfering the outside edge of the old staves back $\frac{1}{2}$ inch and down 3 inches; this joint was caulked with oakum to a depth of 1 inch and then poured until full with melted asphalt roofing pitch.

The new work was erected and the tanks filled with water in six days, and one week later practically all leakage had stopped.

This work was completed about nine months ago and since then has passed through very hot weather and the most extreme cold weather of which we have record and now shows no sign of leakage.

This increase of 3 feet in the depth of settling tanks has permitted us to install both inlet and outlet controllers and to overcome the other difficulties caused by lack of head on the filters and in addition has given about forty-five minutes longer sedimentation.

A RELIABLE PRESUMPTIVE QUANTITATIVE TEST FOR B. COLI

By S. T. Powell

One of the most urgent needs of water and sewage analysis is a reliable quantitative test for B. Coli, which can be carried on easily enough for routine work, and still, although a test that is merely presumptive, will give a relatively accurate count of the number of B. Coli that are present in 1 cc. of the liquid. Owing to the wide distribution of this organism everywhere, it has been shown that it is not the mere presence but the abundance of B. Coli that must be the criterion of sewage pollution. This is particularly true in testing the bacterial efficiency of water purification plants.

It has been the practice at many places of sowing .1, 1 and 10 cc. of water or sewage into lactose bile bullion and depending on the gas formation as indicative of B. Coli. This of course gives some idea of the abundance of B. Coli but is merely a broad presumptive indication as to the number of these organisms that are present in 1 cc. Planting upon litmus lactose agar, or bile agar, and isolating all pink colonies that develop will of course give an accurate count of the number of bacilli, but this process is long and, owing to the routine work necessarily required in the operation at most purification plants, this method is quite impossible, unless the bacteriologist in charge has plenty of assistance.

The writer for some time has been endeavoring to obtain a reliable test that could be performed so easily that it would not greatly increase the daily routine work, but would furnish accurate results. A number of culture media were tested, among which were litmus lactose agar, bile agar, Dragalski Couradi's, and Endo's. The results obtained from this last medium have proven so interesting that it is believed that the details will be of interest to many members of the association doing work of this character.

The preparation of Endo's medium, as given by Hiss and Zinsser,[1] is as follows:

1. Prepare one liter of meat infusion, three per cent of agar containing 10 grams of pepton and five NaCl;

[1] Hiss and Zinsser, 1911.

Table showing results of test

LABORATORY NO.	SOURCE OF CULTURE	MORPHOLOGY						CULTURAL CHARACTERISTICS									BIOCHEMICAL REACTION						
		FORM				STAINING REACTION		BROTH		GELATIN				AGAR-AGAR			LACTOSE AT 40° C						
		Bacillus	Coccus	Spirillum	Motile	Water dyes	Grams	Sediment	Acid	Plate	Stab	Slant	Liquefied in days	Plate	Stab	Slant	Gas formed	Acid formed	Percent H—Co2 approx. 1-2	Dextrose gas formed	Reduction of No. 3 to No. 2	Indol produced	Growth on potato
1	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
2	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
3	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
4	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
5	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
6	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
7	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
8	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
9	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	+	+	+	+	+	+	+	+	+	S	+
10	Patapsco River	+	−	−	+	+	N	+	+	−	+	+	+	+	+	+	+	+	+	+	+	−	N T
11	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
12	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
13	Patapsco River....	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
14	Patapsco River....	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	S	+
15	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
16	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	S	+
17	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	S	+
18	Patapsco River	+	−	−	−	+	N	+	+	+	+	+	+	+	+	+	+	+	1-3	+	+	+	−
19	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	S	+
20	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
21	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
22	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
23	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+

24	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
25	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
26	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
27	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
28	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
29	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
30	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
31	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
32	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
33	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
34	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
35	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
36	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
37	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
38	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
39	Shallow well	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
40	Excreta	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
41	Excreta	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
42	Excreta	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
43	Excreta	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
44	Excreta	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
45	Excreta	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
46	Excreta	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	N	T
47	Excreta	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	N	T
48	Excreta	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	N	T
49	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
50	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
51	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+
52	Patapsco River	+	−	−	+	+	N	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+

− Test negative; + Test positive or characteristic of B. Coli. N Grams negative; N T No test; S = indol test slight.

2. Neutralize and clear by filtration;

3. Add 10 cc. of a 10 per cent solution of sodium hydrate solution in order to render alkaline;

4. Add 10 grams of C.P. lactose;

5. Add 5 cc. of saturated alcoholic solution of fuchsin, filtered before using. This colors the medium red.

6. Twenty-five cubic centimeters of 10 per cent sodium sulphite solution. This again discolorizes the medium, the color not entirely disappearing, however, until the agar is cooled.

Put into test tubes, 15 cc. each and sterilize and keep in the dark.

The colonies of B. Coli are pink upon this medium.

From the table given herein it will be seen that of the 52 pure cultures obtained from pink colonies that developed upon this medium 49, or 96.2 per cent were positively confirmed as B. Coli.

The technique followed in isolating the organism was to sow the sample first upon Endo's and incubate the plate at 40°C. for twenty-four hours. Each pink colony that developed upon the medium was then fished and inoculated into a tube of bullion. This culture was then incubated for twenty-four hours at 40°C. and this was then used as the pure culture from which confirmatory tests were made with the media reported in table; no culture was reported positive until it had been confirmed as a short bacillus, motile, staining with the water dyes but grams negative. Showing characteristic growth upon potato gelatin and agar plates, slant and stab culture not liquefying gelatin in fourteen days at 20°C. Producing acidity and gas in lactose and dextrose bullion with a gas formula of H to CO_2 as approximately, 1–2 also producing indol in Dunham's solution and the reduction of nitrates to nitrites (see table).

The results, meager as they are, show this medium to be of great value for this particular character of work and one which is worth investigation by water analysis.

The high percentage of positive tests reported in this paper refers, of course, merely to B. Coli as a group, which will account for the greater number of positive tests than have been reported by other investigators, who have conducted more lengthy experiments.

Considering the number of specimens and the various forms of B. Coli that have been isolated by bacteriologists, it is doubtful if it pays to isolate these various forms from samples of water, especially considering the labor involved. Until there is a test that will readily and accurately separate the form of B. Coli from other allied organisms, all such bacilli in water, if at all numerous, must be considered

as a serious pollution to the supply. For this reason it is apparent that a reliable quantitative test for this particular group of organisms is of more value than qualitative methods even though the quantitative test may be of a presumptive character.

In the writer's opinion Endo's medium is well suited for this work and gives a higher number of positive tests than most of the culture media in use.

FORTY-EIGHT INCH WOOD STAVE FORCE MAIN BUILT FOR THE WATER DEPARTMENT OF ATLANTIC CITY

By L. Van Gilder

In preparing this paper for your consideration it has been the writer's aim to make it descriptive rather than technical, believing that you have all given the subject sufficient study to establish to your own satisfaction the practicability of wood stave pipe if used under reasonable conditions.

It may perhaps be interesting to review briefly the history of the Atlantic City water department in order to show the reasons for building a wood stave main.

In 1882 the original franchise holders, headed by R. D. Wood and Co. erected a pumping station on the mainland and laid a 12-inch cast iron main to connect with the city, a distance of approximately 26,000 feet of which about 2000 feet was laid in sand, the balance across salt marsh.

In 1888 a 20-inch cast iron main was laid parallel to the first main, to provide for the city's growing demands.

In 1895 the city purchased the property and franchise together with a small artesian well plant within the city limits, operated by an independent company and since that time the water department has been owned and operated by the municipality.

In 1901 the city had outgrown the economic capacity of the old mains and a 30-inch riveted steel main was laid parallel to the other two.

After careful investigation the board of water commissioners and Superintendent W. C. Hawley, now of Wilkinsburg, Pa., had recommended building a continuous type wood stave main, but the city council (then supreme) overruled the recommendation and adopted steel.

Within two years pit holes began to appear in this pipe and it is now, after eleven years of service, in such a condition that extensive repairs must soon be made or it must be abandoned.

In 1906 the first steps were taken toward building a new and larger force main both as a precautionary measure and to lower the peak load friction head.

The cast iron mains were materially weakened by softening on the outside and the steel main was rapidly nearing the end of its usefulness, therefore the department, now wholly under the control of the board of water commissioners, decided to lay a 48-inch wood stave main, as being the most economical, easiest to repair, least flow friction and having the least effect on the water carried.

As to the durability of the wood there could be no question, years of experience with piling, telegraph poles, etc., having shown that every variety of wood embedded in salt marsh was preserved indefinitely.

The bands and saddles were the doubtful parts, but since there was every reason to believe that they would have an average life of from ten to twelve years and could be replaced if taken in time without putting the main out of commission it was decided that a wood stave main should be built.

Of the two types of wood pipe in general use the spiral wound factory made was not considered advantageous for the three following reasons:

1. Because the thin flat bands present a much greater ratio of surface to net section than round rods, hence more rapid corrosion.

2. The failure of a band in one place would endanger a whole section.

3. Because of the difficulty of satisfactory rebanding with the pipe in service.

As general experience with structural wrought iron and steel has shown the former to be much the more durable when exposed to the weather or to salt water, no consideration was given to the latter, although its adoption would have effected a material saving in contract price.

The saddles were malleable castings, weighing about two pounds each, one saddle for each band.

The bands were $\frac{5}{8}$-inch round wrought iron of from 45,000 to 52,000 pounds per square inch ultimate tensile strength and spaced 2 inches on centers at the intake end for a maximum working pressure of 65 pounds per square inch.

To provide for uniform strength of band throughout, the threaded end was upset for a standard $\frac{3}{4}$-inch nut and numerous tensile tests showed no weakness incident to threading.

The bands and saddles were heated and dipped at mill and foundry in hot asphaltum, dipped again in the same material before assembling

and were hand painted with cold asphaltum paint after coopering and cinching.

The wood selected was Washington fir although bids were invited and received on California redwood, long leaf yellow pine and white cedar.

The staves were run from 2-inch by 6-inch rough stock and were finished $1\frac{5}{8}$-inch thick with straight radial edges, 29 staves to the circle. No two adjacent staves were butted in the same transverse plane and all butt joints were sealed by inserting $\frac{1}{8}$-inch by $1\frac{1}{2}$-inch galvanized iron tongues in tight fitting kerfs sawed in the stave ends. These tongues were somewhat longer than the kerfs in order that they would be slightly embedded in the edges of the adjoining staves.

Manholes were inserted at intervals of about 1000 feet and each manhole was made up of one 48-inch by 16-inch flanged tee, one 16-inch blank flange and two 48-inch flange and bell pieces. The staves were entered in the bells and were jointed with jute and lead. With care taken to pour the joints full and solid no trouble has been experienced with them although for extra security the bells were cast 6 inches deep.

All flange joints were made with lead gaskets and bronze bolts, the latter being especially desirable to resist the action of salt water.

The right-of-way chosen involved crossing three navigable streams beside as many drawbridges and while the war department permitted us to lay the pipe on trestle work from shore to channel we were compelled to leave open water the entire length of the draw span and the full depth of the channel, the maximum being about 105 feet wide and 13 feet deep at mean low tide.

These channel crossings were made by ending the wood pipe in a manifold at each side of the draw and laying four 24-inch inverted siphons across the channel, the manifolds and siphons being supported by piling.

Each manifold was made up with one 48-inch by 48-inch by 48-inch by 24-inch cross, three flanges, one bell, three 48-inch by 48-inch by 24-inch flange tees and two 48-inch blank flanges, all of standard patterns. A valve was bolted to each 24-inch manifold flange and the siphons were made up of 24-inch flanged pipe and quarter bends.

By this arrangement a leaking siphon can be put out of service and be repaired at pleasure without seriously impairing the efficiency of the main. The only difficult feature of this construction was to pro-

vide sufficient resistance to prevent blowing the manifolds off the pipe at the bells. This difficulty was overcome by providing sectional cast iron clamp collars, one behind each bell shoulder and two on the pipe at short distances apart, the frictional resistance of the two pipe collars when transmitted to the bell by tension rods being sufficient to balance the thrust. As an extra precaution concrete anchor blocks and tie rods were also provided.

The weight of the pipe as built was about 185 pounds per lineal foot and the only foundation required was a line of 1-inch by 12-inch boards doubled break joint fashion each side of the trench with light cross timbers at about 8-foot intervals, this also provided a convenient footway for the workmen through the soft bottom.

It is interesting to note that the weight of this pipe when full is approximately 970 pounds per lineal foot whereas the weight of a 48-inch cast iron main, class B, A.W.W.A. specifications, is about 1565 pounds per foot filled.

All manhole castings are carried on pile foundations and as the piling and caps are below water level their preservation is assured.

The contract price of the wood stave portion of the main including trenching not less than 30 inches deep across the marsh and backfilling not including extra embankment was $5.28 per lineal foot. All manhole castings were provided and set for $458.51 each and the cost of each thoroughfare crossing including about 400 feet of creosoted pine trestle work to carry the pipe to the manifolds was $25,857.25.

Work was begun on this main March 15, 1910. It was put in service July 10, 1911, and has been in constant service since.

No trouble has been experienced with the wooden structure and the leakage has been practically nil.

The thoroughfare crossings have given some trouble, but we believe the weak points have been overcome.

After two years of exposure the bands and saddles do not show serious corrosion and while it is too soon to make any reasonable prediction as to their durability, their present condition appears to justify the original assumption that extensive rebanding would not be required under ten years.

EXPERIENCES

Mr. W. F. Wilcox: In the matter of pollution of streams, the speaker thinks possibly he is in a little closer touch with what is being done along that line than are a good many of you gentlemen. He will trespass on your time for a few moments to tell you what has come under his observation. It was stated before the Engineers' Club in Pittsburgh about sixty days ago that taking the number of grains of sulphuric acid in p.p.m. and reducing it on the basis of the volume of the Youghiogheny River, there is passing the city of McKeesport in one day as much as 63 tons of sulphuric acid.

It has been stated by men who have gone into the matter that more free sulphuric acid goes down stream from the several coal mining and steel manufacturing plants along various rivers than is manufactured by all the fertilizer companies in producing fertilizer.

Now we can do a great deal by coöperation, and that is the speaker's idea in now taking up your time. The coal mine operators' association is going very deeply into the questions affecting the health and efficiency of the miner. They have their physicians and their engineers. The gentlemen who are really trying to purify the streams and who are spending money to prevent stream pollution are now turning it over to the engineers. There will be held at Birmingham, Alabama, on the 12th instant, a meeting of the Coal Mine Operators' Association of Alabama. The operators maintain at their plants corps of men trained to give first aid to the injured. They are taught how to resuscitate men who are overcome either by water or gas, to tie up an artery when a man is bleeding to death and to perform all first aid relief, and through this they are often able to save human lives and to prevent deaths occurring while the injured are waiting to be carried to the hospital. There is hardly one of these operators that does not have an ambulance standing in the stable all day ready to rush to the aid of the injured. In cases where mining towns do not have sewerage these operators are putting in concrete vaults into which all the offal is put and removed daily and either destroyed by incineration or by carrying it away to some distant point and burying it. The speaker thinks it would be well if this association would place itself in touch with such organizations as the Alabama Coal Mine Operators' Association and show them what we are doing, and let them

show us what they are doing. While we are talking they are spending money; while we are thinking they are doing something. You would be surprised to know the amount of money they are spending. They figure that even looked at from a selfish standpoint they are making money by keeping their men in a healthy condition always ready to do a good day's work. The more able-bodied men you have the less inefficiency, and the higher percentage of work done. It is not a question of cutting down the number of men employed, but the object is to get the largest output from each factory and mine. The speaker thinks these efficiency studies are very interesting. If you will follow what these coal miners' associations are doing in Pennsylvania, Virginia and Alabama, you will find that they are spending their money to prevent the pollution of streams. One company has laid 8 miles of main to take the waste from a byproduct coke plant out of a stream. They have a regular water works system. A good many men that are operating water works systems have not the number of miles of mains that they have at those plants to carry off the waste. We would act more intelligently and push our own cause further along if we got in closer touch with some of those coal operators' associations.

Mr. Leonard Bauer: The speaker is practically a new man in the water works line. We had a little trouble a few weeks ago when an application was made for a hydraulic elevator. The speaker looked over the rules of the department and informed the applicant that they had to get a meter. The elevator people said that meters were never installed with hydraulic elevators; that the water was measured by an indicator. The speaker said that there was no authority under the water works department rules to accept any indicator measurement. They contended that such indicator measurement had always been accepted. A delegation of business men who were interested in buildings where these elevators were operated called on the city officials and wanted to know why they could not continue using their indicators. We assured them that we would thoroughly investigate the matter. If there is any one here who has had experience with these indicators on hydraulic elevators as to their accuracy in measurement, the speaker would like to hear from them as he wants to get as much information as he can on this question.

Mr. M. L. Worrell: The speaker can answer that in a few words. He has had indicator readings that made the charge $3 to $7 a month, and when the meter was put on the bill went up to from $35 to $90.

MR. ROBERT L. CLEMMITT: At one time we had a great many indicators on elevators in Baltimore, but found them so unsatisfactory that practically all have been removed.

An indicator is a mechanical instrument which will give good results when properly adjusted and in good condition, but they are easily tampered with. They can not possibly account for leakage, or water that may be taken from taps on the service pipe to the elevator. The speaker would advise the use of any of the current or velocity meters on the market in preference to an indicator.

MR. F. H. SHAW: The speaker has one of those plunger elevators in which the registration depends upon a rack, and about 3 feet of that rack disappeared causing no registration between the basement and the second floor.

MR. WILLIAM R. YOUNG: We have had a great deal of trouble in Minneapolis with hydraulic elevators on account of the recoil. The elevator people say proper air chambers on an elevator would prevent recoil. The speaker thinks that that is true provided an experienced man is running the elevator and runs it carefully so as to prevent any trouble. But operators are not always careful, and we have practically denied all applications for hydraulic elevators in Minneapolis, and have even discontinued them where they were in when services were over 2 inches. Where we had indicators on the larger ones and have replaced them with meters, the bills have been so enormously high after the meters were on that it has proved a good way of getting rid of the hydraulic elevators. We had some forty-five or fifty of them three years ago, and at the present time we have only eight that have connections larger than 2 inches. With the 2-inch pipe the friction is so great that the recoil does not seem to have much effect on the mains or on the meters.

PRESIDENT GWINN: In Terre Haute we had thirty hydraulic elevators, and you can imagine the effect upon the pump when half of those elevators were operated at the same time. We discouraged the idea of hydraulic elevators, and when a man comes to us asking for a lower rate and objects to his bill we tell him to put in an electric elevator. So, gradually, we have gotten the number down to about seventeen. We would rather take our chances with the slip of the meter, proportional meter or otherwise, than with the registration of a counter. We had rather a disastrous experience with one elevator

that had counters on it. After we put a meter on the service pipe we found that the consumption of water was 80,000 gallons a day, whereas under the counter registration it was about 5000. The only safe plan in the speaker's opinion of furnishing hydraulic elevators is to keep the size of the connection down to about three inches, and supply the elevator with a meter, then you are sure of being paid for what you furnish, providing you charge a reasonable minimum rate to begin with; this should be at least $10 per month.

Mr. John Caulfield: We had a few hydraulic elevators in use, but we discontinued them, because of the danger of loss by lawsuits, liable to arise on account of furnishing water for this kind of service. The speaker suggests that each water department examine its franchise and see whether it has authority to furnish water for such use. The question was brought up in our courts, and it was charged that we were furnishing water power, and the court intimated that we had no authority to furnish water power under our franchise. So that any water departments that are furnishing water power ought to be very careful to find out whether they have authority to furnish water for power or only for domestic and mechanical purposes.

Mr. F. H. Shaw: There would be a chance to get after the motor washing machines.

Mr. John Caulfield: Do not know that we have any of them. When anybody asks us about a washing machine we merely reply that we do not permit them.

Mr. E. E. Davis: We had a few elevators in Richmond that were supplied with indicators; there are none in use now. The speaker has always been opposed to them. He went in and looked at one once, and as a result went back to the office and ordered a meter to be put on that service. He thinks that elevator ran about two months after he put the meter on. A man asked him, "Where do you suppose that water goes to?" He found that there was more water running away by leakage around the plunger than he was paying for. Whenever you find one of that kind of elevators he suggests that you put on a meter, and they will stop running them, because electric power is much cheaper than water for that purpose.

Mr. W. F. Wilcox: The speaker wants to give you the experience he had on a different subject. These little fellows like Caulfield

over there have troubles, but the speaker has troubles too. One of them came up in regard to the quickest way of breaking out large sized pipe. We have pipes 30-inch, 36-inch, 42-inch and 48-inch in diameter, and when any of them are broken we have to hurry up and fix them. Now if you strike a piece of pipe 2 inches thick it is right hard to break it although you may have developed a flaw in it. We have adopted a plan of dynamiting out a broken section. Have any of you dynamited any sections of broken pipe?

As can be readily understood shutting down a large industrial plant on account of lack of water is an expensive procedure, thus anything that will expedite repairs in case of a break in a main is of material value.

Starting in the center of the pipe to be removed, place one-fourth to one-third of a stick of 40 to 60 per cent dynamite on top of the main and cover it with a handful of clay. The blast blows out a small hole or starts a crack. Further shots are shot off working toward each end of the pipe. By this means four pieces of 42-inch and one each of 36 and 30-inch pipe have been removed from the line. As some of the pipes were 2 inches thick a heavy sledge made little impression on them. Twenty minutes after starting to blast the pipe is ready to take out. The speaker suggests experimenting on broken or scrapped lengths.

It is also suggested that electric exploders be used as they are safer and also more readily used, and fused exploders are uncertain and often dangerous. An ordinary battery such as is used in coal mining will cost about $15 and will last a lifetime.

Mr. J. M. Diven: Have you ever considered the advisability of laying two smaller pipes, equal in capacity to one of larger size? When we get to the larger sizes the pipes are heavy and thick, above 42-inch the price per ton is usually increased.

Mr. W. F. Wilcox: Right now we only have single lines. When we get close to the plants, then we double the lines; but on the main line we depend entirely on air chambers. The design of air chambers on pipe lines is a question the speaker had occasion to look up. We have a 50-inch main 9000 feet long under 100 pounds pressure. When the pump plunger was operating under its highest speed the main was perfectly round, as the speed of the plunger decreased the main would assume an oval section, the variation in figures being $\frac{1}{16}$ inch. The speaker was worried as he stood and watched that pipe "breath-

ing," the movement being like a man's chest. He investigated and could not find any literature on the subject of air chambers. He finally found an old English "rule of thumb" which says that your air chambers should be five times the capacity of your displacement; therefore if you make your air chamber five times the size of your water cylinder it would be perfectly safe. Following that rule he put a large air chamber on the pipe line with a $\frac{1}{2}$ x 12-inch gauge glass on the side and the column of water in this glass does not vary $\frac{1}{8}$ inch.

Mr. C. E. Abbott: The speaker employed an economical method in laying about 10 miles of pipe, 4 to 12 inches in size, that he would like to tell about. The pipe was lined up on the top of the trench by putting 2 x 4's across it, ten sections at a time, fitted up by differential blocks and lowered into the trench. On this special job he laid 10,137 feet of 12-inch pipe, beating the contractor's price on it by $1138.06.

A man who has a lot of pipe to lay can lay a block just as easily as he can ten lengths. The speaker found that his men caulked up a joint in exactly half the time that they did in the trench. It eliminates cutting bell holes and you get a quicker and better job and better alignment of your pipe. One derrick was used for each two lengths of pipe.

President Gwinn: You couldn't use leadite on that?

Mr. C. E. Abbott: No, sir. We didn't do any recaulking, we didn't have to go over a joint.

President Gwinn: We would like to get the cost per foot under that method, Mr. Abbott.

Mr. C. E. Abbott: The same men that lined the pipe up over the trench moved the derricks, five men. The whole job complete, labor without materials, cost $1918.24 for 10,137 feet, practically 10 cents a foot, including back filling and all.

Mr. William R. Young: The city engineer of Minneapolis and a member of our fire committee wishes to have something brought up before this convention that will bring out information that they would like in regard to the desirability or otherwise of putting in

larger fire hydrants than are at present in use in Minneapolis. We now have 6-inch branch 5¼-inch barrel fire hydrants, with two steamer connections. Some question has been raised with regard to putting in larger hydrants especially in the business district. Last winter they took bids for 6¼ and 8-inch hydrants. We were a little bit misinformed in regard to larger hydrants and when we asked for bids we found that hardly anybody made 8-inch hydrants as they seemed to be so out of proportion to ordinary needs. Later on the question came up again and the matter was laid over until after this convention to see if we could get some information as to whether 6¼ inch would be preferable to what we are using, or larger size if necessary.

Mr. J. M. Diven: This association has a committee on standard specifications for fire hydrants, and their report should give the information you ask for. Do you attach two steamers to one hydrant? You speak of their having two steamer outlets.

Mr. William R. Young: We put as high as three on one hydrant. We put two steamers to one connection a great many times.

Mr. J. M. Diven: Would it not be better to have more small hydrants distributed at shorter intervals? You might have a fire on one side of the street and the heat might be so intense that the engines could not stay that close to the fire, whereas if there was a hydrant on the opposite side of the street they could get further away from the fire. The speaker's choice would be to have a large number of hydrants of a smaller size, single steamer size, rather than a less number of larger sized hydrants.

The 5¼-inch hydrants will supply all the water any steamer now designed can use.

Mr. William R. Young: We have two double steamer hydrants on each cross intersection, also one in the middle of each block.

President Gwinn: We have three at some intersections and sometimes two in the middle of the block. The speaker's advice would be to put in more hydrants of standard size instead of getting unusually large hydrants and having a lot of engines standing around in one particular spot.

Mr. William R. Young: The question comes back to whether it would be better to use a 6¼ or 5½-inch opening.

Mr. A. A. Reimer: We have adopted for our standard now nothing smaller than $5\frac{1}{4}$-inch for the 2-way and 3-way hydrants, and $6\frac{1}{4}$-inch for the 4-way hydrants, with 6-inch leads as the smallest. In case of a 4-way hydrant where the lead exceeds 23 feet in length we use an 8-inch lead from the mains. If we are on a 6-inch main and we put on an 8-inch lead we get an equivalent to two directions of flow, and we believe we are getting the best results possible from that type of hydrant. We do not use steamers at all. We use direct pressure. And the same theory would cover steamers.

Mr. F. H. Shaw: We have set about forty or more hydrants with 6-inch leads, with one $4\frac{1}{2}$-inch steamer connection and two $2\frac{1}{2}$-inch hose connections. We put them in diagonally across the street at street intersections and at half way points. The cost averages $82 per hydrant which is less than the cost of two lengths of fire hose, but the hydrant is good for fifty years whereas the fire hose might not be good for more than five years. I think you can afford to put in more hydrants and save hose.

Mr. R. L. Clemmitt: In regard to fire hydrants the speaker thinks the insurance people take the same view as they do about fire service pipes and want hydrants with the largest possible tail pipes regardless of the fact that a hydraulic calculation or practical test will demonstrate that an ordinary hydrant with a 6-inch tail pipe will under normal city pressure of 40 to 50 pounds supply all the water that the largest fire engines can dispose of.

A DISCUSSION OF DEPRECIATION AND A COMPARISON OF RATES AND BOOKKEEPING METHODS OF MUNICIPALLY AND PRIVATELY OWNED WATER WORKS

Mr. John W. Alvord: The Depreciation Committee had certain conferences during the year and some correspondence with each other, and had under way several important matters which the committee expected to lay before you in furtherance of their studies of the matter of depreciation. These matters will undoubtedly be put into shape by Mr. Metcalf just as soon as he is able, and will appear in the printed proceedings.

It might not be improper, however, for the speaker to suggest in advance one or two of the lines of thought that the committee have had under advisement.

The first of these points is as follows:

We have been asked by administrators of water works properties why they cannot make good depreciation in lump sums out of income when the income becomes large enough so that such depreciation investments can be made good, and especially where the proper sinking fund could not be set aside in the early life of the business because it was not earned. It is understood, of course, that these depreciation investments are not additions to capital account, but are strictly renewals of worn out or useless structures, and the operation may be regarded as in the nature of replacing a depreciation fund which should have been accumulated, but could not be accumulated as a matter of fact.

It is evident that this method is not providing by a sinking fund, but an attempt to make good such sinking fund. But is it not due to the plant that it should maintain itself, as has been held by the Supreme Court of the United States in the Knoxville case? And may not such maintaining be in the form of renewals made at times when the income is sufficient and available for replacements?

This is a fair question, and is before the committee for consideration.

A second question which the committee is deliberating upon is, if depreciation funds have not been set aside from the beginning of the life of the plant so that in valuing such a plant we must deduct what is lacking from the original investment, it is evident that the

property will not be maintained if rates are continually predicated upon the new reduced values so found. This in itself is not unjust from the point of valuation, because if the depreciation has been earned and has not been set aside, the owners have withdrawn it from the plant; but if a plant valuation should be made every year (as is usually the case in California), and it should be found that no depreciation funds had been accumulated, would not the reduction in the investment and each new rate predicated thereon tend to lessen rates to a point where they are inadequate to maintain the property, because they will be reduced to such an unremunerative basis as to destroy the original investment, when as a matter of fact the plant may be nearly as capable as ever of performing the service and pumping the water almost up to the time when it must be entirely renewed.

To illustrate this point: If a plant whose life is theoretically three-quarters over should be considered, it will be usually found that only a slight diminution in its *earning capacity* is affected by reason of its age; and while it is possible that a sum should be accruing to replace it at a certain time, it by no means follows that the structure or plant is not capable of performing almost as good service as ever it did, in most circumstances.

Now if theoretical depreciation were deducted from the value of such a plant annually on a sinking fund basis there would certainly arise the incongruity that the value of the plant would be largely extinguished at three-fourths of its life, when in fact its earning power may be greater than ever.

This also is a question to which the committee has given some thought and some attention, and is a practical question from the operating point of view as well as in all cases where fair rates are involved.

A third question is the question which has often arisen as to whether rates for sinking funds in the future should be computed at the same amount as they can be computed for in the past? At first blush it would seem the logical thing that they should be computed precisely in the same manner; but upon second thought it will be remembered that we are able to closely follow the actual history of the losses in value which have occurred in the past, knowing much if not all of the contingent and surrounding circumstances which have affected the value of the different portions of the plant, while we have no such foreknowledge as to the future.

The question therefore arises, Are we not justified in computing the sums to be set aside for past depreciation on a closer basis, that is to

say, a narrower margin, than we are in computing what funds for depreciation must be set aside in the future where we must confront the possibilities of unknown contingencies, the history of which has not yet been developed?

This is an interesting question in rate cases, and it is *the* important question in advising managers what depreciation to set aside for the future.

MR. J. N. CHESTER: The speaker is greatly interested in this subject. He believes that the percentage of municipally owned plants who keep their books in such a way as to properly show depreciation is very small as compared with the private plants. Of later years their records have been more carefully gotten up, and in many of the eastern states they are now compelled to file with the secretary of state a statement of what they are doing and what the result of their operation has been. Nevertheless we find that not more than half of them show a charge for depreciation.

Just how depreciation shall be accounted for, or how it shall be invested or used, is of course a subject as to which there is a wide difference of opinion and ideas. The speaker's own experience and practice is to show upon the books the full amount put into extensions, and then to reduce it by an entry in another column of a certain amount for depreciation. What that depreciation percentage should be is a question that is open to a great deal of debate, and in regard to which we find experts differing very widely. The speaker is afraid if we settle that question here we might deprive some of the experts of occasional fees, so he warns you not to go too deep. It is in the municipal plants that we are suffering the most. He says "we" because he is on both sides of the fence.

When private water works affairs are aired in court they are always measured by the success of a nearby municipally owned works; and almost invariably when we get into the affairs of such municipally owned works we find that there has been no charge for depreciation and a great many other things that privately owned works are expected to account for in the making up of their annual reports.

The speaker does not know what we can say or do that is going to entirely correct this. He believes that this association is made up more largely of representatives from municipally owned water works than privately owned water works; so that a healthy discussion of the question here might result in the adoption of something worth while. He believes that a great deal can be done to alleviate or relieve

certain features of the situation which confront us every time we must face it.

MR. H. B. MORGAN: It is a question we have been threshing over for several years, and as the gentleman just stated, we have had experts with widely differing views on both sides, both in court and out of court.

The speaker differs somewhat with the gentleman on the proposition of taking the cost of extensions out of the depreciation fund. He thinks that the cost of all extensions should be charged to capital account. He knows that experts, in arriving at the value of a plant, do not, as a rule, pay much attention to its cost as shown on the books, yet it has some bearing on the question of value, but the subject of valuation is not before this convention for discussion.

MR. LESLIE C. SMITH: The speaker is exceedingly doubtful as to the matter of depreciation having been carried in any plant, either private or public, to that degree of accuracy which it will warrant; he thinks that conclusion is borne out by the conflicting reports and constant turmoil among those interested in plants, in their endeavor to arrive at any definite conclusion.

In the segregation of the various parts of the plant, whether it be its distribution system, whether it be its pumping equipment, whether it be its holdings, they are so widely different in various parts of the country, that the question after all becomes more or less a local one.

The speaker knows of cities of twenty-five thousand where the life of ordinary class C cast iron pipe is but fifteen years owing to soil conditions; whereas in Cleveland we consider the life of pipe at one hundred years. We have taken up pipe thirty-two years old and found it unnecessary to recoat it when using it, it having apparently suffered no change except a little rust on the outside. So that if you take a distribution system and attempt to compute your depreciation upon it, it appears to be clearly a local matter. After all, for accounting purposes one must adopt some system, some standard that has application to his immediate condition.

Again, the charge for depreciation must depend pretty largely upon what degree of excellence is attained and maintained in the maintenance and upkeep of the plant, and to other local conditions such as each of us must be familiar with.

After keeping up the maintenance to the highest extreme possible,

knowing that we have soil conditions which make for the very best results as to wear and tear upon pipe, the speaker has pursued the custom of charging off for depreciation a gross 2 per cent. He thinks some of you will contend that that is high, but he has adopted that figure rather than to be accused of shirking the issue; he would rather overestimate than underestimate it. He believes that this question is being carefully studied by a number of very competent gentlemen, and that it is only by such study and care that we can arrive at any definite standardization of it.

Mr. W. S. Cramer: We have not as yet adjusted our books to conform to the seemingly perfect system of charging off depreciation as outlined for us in a recent valuation made for our company by Mr. Alvord. Whether he will see fit to change this system as changes of conditions may demand the speaker can not say but at present it is in his opinion very comprehensive and complete.

Mr. J. Walter Ackerman: One speaker referred to the fact that municipal plants are usually a little bit behind in the matter of depreciation. The speaker simply wants to say that the original holding company in Auburn was bought out by the city in 1894, and ever since that time down to the present time the entire original actual cost of the plant and all additions have been depreciated 2 per cent each year, for the want of some better standard. That has been applied to the original purchase price and the cost of additions and replacements, all improvements and betterments, each year. We have done that from the very beginning.

Mr. John W. Alvord: The speaker would like to ask the last speaker whether he adds that per cent to the amount that they should earn?

Mr. J. Walter Ackerman: As the years go on of course our income increases. Instead of taking care of it in that way we reduce our rates, so that our income does not increase in amount but our rates decrease. We have decreased our rates three times since 1894.

Mr. J. N. Chester: Do you allow for operating expenses, interest on your investment at the rates the city must pay, and also for administration of the affairs of the plant, when you charge off for depreciation?

MR. J. WALTER ACKERMAN: The plant while owned by the city is not a part of the general city administration. The water commissioners are a separate and distinct department, and manage their own affairs, issuing their own bonds and paying their own bonds. This was provided for by a special enactment. The only connection we have with the city is that we get a small amount for hydrant rentals. But that is the only amount that is raised by general taxation in our city. The speaker has only been connected with the plant since 1908, although prior to that time he was city engineer and had a slight supervision over the plant.

MR. J. N. CHESTER: No matter who does it, the affairs of the plant must be administered, and there should be a charge set aside for administration in connection with everything else. The speaker's question was whether you collect an amount sufficient to cover interest, operating expenses, depreciation, and a reasonable amount for administration?

MR. J. WALTER ACKERMAN: Yes, sir.

MR. JOHN W. ALVORD: It may be of interest, in connection with the concrete percentages that are being discussed here, to say that in examining a great many plants financially the speaker hardly ever ran across one that was able to actually earn its operating expenses, a reasonable return upon the investment and at the same time set aside a 2 per cent depreciation fund. If there is such a plant he thinks it may well congratulate itself on its good financial condition. Two per cent depreciation is a pretty large depreciation for a water works property consisting as it does largely in stable investment in cast iron. You must realize that this depreciation must be actually earned, it is not something that you can write down on a piece of paper and then lay the paper aside and forget it, you must take care of depreciation in some concrete way by which you can again reinvest funds for the upkeep of the plant. Merely entering on your books a certain amount for depreciation each year is information only as to the amounts the owners are withdrawing from the property which should be used for its maintenance. If you actually provide for depreciation you have to earn that depreciation so that you can spend it for the plant. Unless you do that you are not taking care of depreciation at all. Theoretically the least you can do is to set aside a special fund which at the end of the life of any structure will replace that

structure. The lowest rate at which additions to such sinking fund can be usually calculated on the total value of the property, is from about six-tenths to eight-tenths of 1 per cent per annum set aside at interest. Now, 1 per cent depreciation set aside every year has been, as far as my investigation goes, found impossible in many privately owned plants; this of course in addition to a fair return, taxes, cost of operation and management, so closely do our average private plants sail to the wind. So that first: the speaker does not know of any plant that can set aside 2 per cent for depreciation, and especially any municipal plant, and have it in addition to the return on the investment. And second: he does not see any reason for setting aside so large a sum in water works plants at least, even if it could be done.

Mr. J. N. Chester: The speaker is very glad Mr. Alvord has said what he has. He does not want to be put in the attitude of doubting his friend from Auburn, but he agrees with Mr. Alvord that in examinations of plants he has found none up to date that has been earning as the remarks of the gentleman from Auburn would indicate that city has been. He only wishes that the private water works of this country would be permitted by the population they serve and the municipalities that govern and control them to a certain extent, to earn as Auburn has been earning or as we are led to believe by the remarks of the gentleman it has been earning. He fears that a careful analysis of affairs there would indicate the truth of the remarks made by the speaker at the opening of this discussion with regard to the method with which municipally owned plants keep their records. He is afraid that they do not properly subdivide all of their expenses and allow, not only for the expense of operation and maintenance, but interest and administration charges. Taxes he has always looked upon as a part of operating expenses. Around the city of Pittsburgh there are quite a few privately owned water works plants, and the rates charged by these private companies are in excess of those charged by the city of Pittsburgh, and the lives of those who operate these private companies are made miserable by the constant dingdong of the consumers claiming that within the city of Pittsburgh lower rates are charged for water. In a recent rate case the Pennsylvania Water Company went to considerable expense to find out just what Pittsburgh was doing, and it was shown that the cost of the water served by the city of Pittsburgh to its patrons was far in excess of that of private companies. It was also shown that if Pittsburgh charged

their consumers enough to cover the actual operating expense, taxes, interest, and a fair charge for administration, their rates would have been as high or higher than most of the private water works companies. The speaker has told you that he comes to you from both sides, but we have more clients in the way of municipalities than private water works companies, so he is interested in their welfare. But he asks you who represent municipalities only to be very careful as to what you put on the record here; and that you take everything into consideration; for as Mr. Alvord has told you, we who are examining these things many times a year have yet to find one plant that is making the 2 per cent depreciation that has been stated here by two different people as the percentage that they are prepared to charge off and are charging off. Do you know that they bring the little red book, the annual report of the American Water Works Association, into the courts in almost every case, and quote just such remarks as the gentleman from Auburn has made, to show that if a plant is municipally owned it can charge off 2 per cent and give lower rates, and reduce rates three times since 1894, and serve its patrons fully as well. With all due respect to the gentleman from Auburn the speaker believes that a careful audit of his accounts would show that either his rates were high when he started, or that the charging off is a bookkeeping operation and they are not making it, especially if they had taxes to pay such as a private water works company must pay, and if other expenses were all taken into consideration.

Mr. J. Walter Ackerman: We invested in $58,000 of city bonds last year; and while that $58,000 was not our earnings in excess of our receipts last year they represented part of it. The speaker is not in a position to state that prior to the time that he assumed charge of the plant this was done. He said that that practice of charging off 2 per cent had been followed since 1908 when he assumed charge of the plant. We have laid by in our depreciation fund something like $80,000 in actual money. That is the best argument that the speaker can offer.

Mr. Stuart Wood: The gentleman from Auburn has remarked privately to me that the city of Auburn in calculating the amount of net earnings did not include any allowance for taxes, and those of us who are not so fortunate as to be exempted from the payment of taxes realize that that item comprises a very large proportion of the cost of operating a plant. The speaker is tempted to repeat some-

thing that came under his personal experience when listening to the testimony of a very competent gentleman who was operating a municipal plant. He was testifying on the witness stand and was asked:

"Does your plant make a profit?"

He said, "Oh, yes, we make a handsome profit; about $30,000 a year."

"Yes, and what do you pay for rent for your offices?"

"Oh, we don't pay anything for rent; we occupy rooms in the city hall."

"What does it cost you to collect your accounts?"

"Oh, that don't cost us anything; that is done by the city treasurer."

"When you have legal difficulties, what do you do about your legal expenses; are they charged to your operating expense?"

"Oh, no, that is all done by the city attorney."

And so on. The gentleman was then asked, "Supposing you paid for your office rent, supposing you paid for collecting accounts, supposing you paid for legal expense, supposing you paid for taxes, and supposing you had to lay aside a fund for depreciation, how much would all that amount to?" The gentleman figured it up. He was perfectly fair in his testimony, and was an unusually intelligent man. When he had produced all the figures the examining counsel added them together and asked, "Is that correct?" "Oh, yes, that is correct." "Then with all those things considered, are you making money, or losing money?" The witness answered, "Well, if you count all those things in we are losing money; but please don't publish this in my town, for it would make me very unpopular if you did."

Mr. Leslie C. Smith: The speaker would like to ask Mr. Alvord or Mr. Chester whether they do not consider renewals in the plant as a legitimate charge against depreciation which has been established for the renewals or replacements of structures at the expiration of their life?

Mr. John W. Alvord: To that question the speaker might answer yes and no. There is a certain class of renewals that are very small and we have grown into the custom of charging them to maintenance. There are also much longer lived structures the wear and tear on which we are accustomed to call depreciation and provide for that theoretically by the depreciation fund. It is that class of maintenance or upkeep to which we refer when we talk about this whole matter of depreciation.

MR. LESLIE C. SMITH: That is exactly the point the speaker makes. For instance, in carrying depreciation either theoretically or practically, those of us who have large plants accumulate a less amount of depreciation. The speaker believes that the Cleveland depreciation would be something like two hundred and fifty thousand for 1910; in that year we bought pumps to replace pumps and we considered that that charge in all fairness was a legitimate charge against the depreciation fund, though it is a replacement in fact. But is it not true that the depreciation fund was established for caring for just that sort of thing?

MR. JOHN W. ALVORD: That is precisely the point which the speaker suggested to the depreciation committee to consider. Why should not such expenditures actually be allowed to be considered as replacements, as renewal of the structure if they are accounted for as such and not as capital account? The question has been repeatedly asked; it is an important question to all plants, municipal or private, as to how depreciation should be figured. The speaker thinks the opinion of most of the committee is that certain renewals properly accounted are properly depreciation. If the company or if the city have not kept in hand annually an increasing depreciation fund, they have certainly withdrawn from the business something which belonged to it, by the decision of the Supreme Court of the United States in the Knoxville case. But if, on the other hand, when it comes time to renew some structure and they see fit to put back into the plant the funds for such renewal, have they not a right to show that they have earned it from the rates for a reasonable period of time preceding that renewal? The speaker thinks that the majority of the administrators feel that they have. That is one of the things which the speaker hopes we will have more fully reported on by this committee.

MR. LESLIE C. SMITH: While Cleveland is a municipal plant, in making up its balance sheet, Mr. Chester to the contrary, the speaker believes that a 2 per cent charge, with a full allowance for taxes; for interest; for sinking fund; for depreciation; for renewals; for insurance; for administration; in short for all those things that the average municipal plant omits, has been carefully considered in the Cleveland proposition. The balance sheet of the Cleveland water works plant will show that all those things have been charged off fully. But that depreciation, as he understands it, in Cleveland is

materially reduced every year by maintenance payments. The principle is the same. It is no different, whether it be a $3 replacement, or a $300,000 replacement; so that with the establishment and maintenance of a depreciation fund any charge for replacement is a just charge in his opinion against that fund. Therefore the depreciation fund does not mount up year after year into untold figures; it is held down and kept down. Therefore, while that is in a book sense a maintenance charge, in the balance sheet showing it is not, because it has been cared for and cannot come out of the depreciation and out of maintenance also. It has been his practice to take it out of depreciation.

It must be understood that in Cleveland the proposition is a somewhat simple one. Our water supply is there; all we have to do is to take it and use it. The rate proposition in Cleveland is openly unfair. While protecting the small man, it brings us a vast amount of money from the large user, and by reason of the excessive disproportion collected from the large users the income of the plant is greater than it would be on a thoroughly equalized method of charging. The speaker is not defending the present method of charging for water there, he is stating conditions as they are. The Cleveland income in gross is not represented by a statement of what the cost of the water would be to a domestic consumer.

The speaker repeats again that he will welcome Mr. Chester's investigation any time, because if we are wrong we want to know about it. The profit of the Cleveland water plant for the year 1910, based on this method, was far below 1 per cent, which he thinks all would admit is a fair working basis.

Mr. Theodore A. Leisen: The speaker did not intend to say anything on this matter, not being prepared to discuss depreciation; but the subject as handled by some of the speakers has gone into a comparison between municipally and privately owned plants as to the charges which should be made and included in their statement of expenditures and earnings. If a municipal plant does not have to pay rent, does not have to pay taxes, does not have to pay any of these several charges which unfortunately for the privately owned plants have to be met, he does not see any good reason why such charges should be included in the cost of operation of the municipal plant. The main object of a municipally operated plant should be to furnish water to the consumers at the lowest possible charge or rate consistent with the revenue required for operation and improvements

under the conditions which exist there. If they are fortunate enough to have an office in the city hall and do not have to pay rent, there is no earthly reason why they should include that rent in their rates, and the same holds good with regard to taxes.

As to depreciation, of course every plant, municipal or private, must provide in some form or other for this charge. In Louisville our plant is differently situated from most others. The Louisville Water Company was organized as a private company, and was a stock company up to a few years ago, when the city finally acquired 100 per cent of the stock, but it is still the Louisville Water Company and operated by the board of water works, a municipal body the members of which are appointed by the mayor. It has every charge, except that of taxes, to contend with which a private corporation would have. We have our own offices and property and make our own collections, but we are free from taxes.

Now, without going into a comparison of the rates between this and other plants, there is no question but what the depreciation fund should be worked out on proper scientific principles. Our earnings last year, with a very small depreciation charged off, would still leave room for nearly 3 per cent depreciation, in addition to the amount paid out to the sinking fund for covering all outstanding indebtedness of the company. But in almost every instance when this subject is discussed the comparison between municipal and private plants, and the question of office rent, taxes, and collections is brought up. Now if you are going to appraise a privately owned plant it is manifest to any one that all those things should be taken into consideration, and anybody who wishes to deal with the subject fairly will acknowledge that. Everyone with a fair idea of justice will admit that a private company must charge more for its service, as it has greater expenses; but at the same time the speaker does not think that a municipal plant should charge high rates just because a private company must do so. In the valuation of a plant these things have to be taken into consideration; but in the operation of a municipal department its charges should be as low as it can make them consistently.

MR. H. B. MORGAN: Does the speaker understand the gentleman to say that a municipally owned plant should not charge any rates in excess of operating expenses; is that your position?

MR. THEODORE A. LEISEN: No, sir; if you understood that it was contrary to what the speaker intended to convey in his statement.

What he contended was that a municipally owned plant should base its rates on every expense which it has to meet, plus a certain amount for contingencies and improvements.

MR. H. B. MORGAN: And depreciation?

MR. THEODORE A. LEISEN: A certain amount in addition to the maintenance for any replacements which have to be made.

MR. H. B. MORGAN. How much would the Louisville plant have earned last year over 2 per cent after paying operating expense and all charges?

MR. THEODORE A. LEISEN: Probably 4 per cent.

MR. H. B. MORGAN: Then you are earning about 6 per cent, not considering depreciation?

MR. THEODORE A. LEISEN: About that rate. We earned in 1911 $436,341 over and above all operating expenses including interest and sinking fund charges. Assuming the total value of the plant at $8,000,000, this would represent net earnings of $5\frac{1}{2}$ per cent on the invested capital, although all of the capital invested with the exception of $1,500,000 has been paid off through the sinking fund. If we assume an annual expenditure of $116,000 for improvements, then the net balance of $320,000 would represent 4 per cent on the capitalized value of the plant, which could be charged to depreciation, profit or any other fund which the ingenuity of the bookkeeper might choose to devise.

MR. H. B. MORGAN: Do you think it is fair for the city to make a rate that will only earn 2 per cent over depreciation and operating expense on the value of the plant?

MR. THEODORE A. LEISEN: Not as a regular proposition, no.

MR. H. B. MORGAN: The speaker understands from the remarks of his friend from Cleveland that the Cleveland plant can stand 2 per cent depreciation. If he is not mistaken the gentleman from Cleveland states further that over and above that about 1 per cent was laid away. That is 3 per cent. He admits that their method of charging rates is unfair. The speaker thinks he is right about that; as he understands it the Cleveland proposition is that they charge the man who

uses 1000 gallons per year the same rate per 1000 gallons that they do the man who uses 1,000,000 gallons per year, which of course is unfair to the large consumer on the one hand, and on the other hand is unfair to the water department because the rate is too low. The speaker thinks that he will admit that the consumer that uses a small amount of water should pay more per 1000 gallons than the one who uses a large amount.

Just to show you that the gentleman from Cleveland *is* a friend of mine, we occupied the same room in the hotel last night. In other words, the privately owned plant was able to sleep in the same room with the municipally owned plant.

MR. LESLIE C. SMITH: I object to being called a "plant."

MR. H. B. MORGAN: The gentleman's objection is sustained; the speaker did not intend to call him a plant.

The speaker does believe we should not get in our minutes statements that are unfair. He does not think that the gentleman wanted to be unfair in any of his statements, but anything that goes out in our minutes will be quoted, and the speaker has heard of their being used in court. The speaker thinks it is wrong for gentlemen to make such statements unless they explain them. Therefore, he is glad that Mr. Alvord and other gentlemen here, myself included, have asked these questions, so that the explanation can accompany them. The speaker does not think that either the gentleman from Cleveland or the gentleman from Louisville want to be unfair.

MR. J. DAVIS BARNETT: May the speaker ask whether depreciation means wholly wear of metal and rust, or does it include that loss to a plant which comes from the growth of a system? He is thinking of a small town that puts in an equipment suitable for a population of ten thousand. That equipment answers every purpose until the population gets to be twenty thousand and then it may be necessary to lay another main and take the old one out, and to increase your pumping power. He would like to know from our experts who have been working on that subject whether the loss to the plant which comes from the growth of a city is in these figures included under the head of depreciation.

MR. J. N. CHESTER: If the gentleman who has asked the last question will consult the recent pamphlet sent out, the minutes of

the last meeting, containing the report of the committee on uniform accounts of water works he will find the term amortization made use of, meaning something dead, in our discussion here we have included such in depreciation. The speaker believes the word amortization covers about what the gentleman refers to.

Going back to the position taken by Mr. Leisen in regard to this matter of not charging rent for quarters in the city hall and for collections, or for the services of the city attorney, is it not true that the city would have to have a larger city hall in order to accommodate the city water department, would it not need a larger legal force or pay the city attorney more money if he looked after the affairs of the water works as well as his other public duties? Then should not this additional cost be a legitimate item of cost to be considered? If the water works department pays no taxes does not a heavier burden fall on the people in some other direction? When you get to balancing municipally and privately owned plants as to cost of maintenance, there is no difference in them except that the city may get the benefit of an interest rate of 4 per cent as against a higher rate that would be charged the private company. When you talk about the city paying 3 per cent on its bonds you will have to figure that the private company would pay 4½; if the city paid 4 per cent the private company would have to pay perhaps 5 to 6 per cent. If the water is shut off for non-payment of rates, in a municipally owned plant it is collected by the delinquent tax collector, whereas, the private company would be subjected to legal cost to enforce its collections.

The gentleman from Auburn corrects the speaker and says $6 per capita. If you were to permit a private water works to earn $6 per capita they could do just what the gentleman from Auburn says they are doing there. The gentlemen from Cleveland and Louisville have many advantages that plants in small towns of two or three thousand people have not. Local conditions count for a great deal. In one place you may have to operate against 20 pounds pressure, in which case you must be in a prairie town. If the city is located on a level it would not present the difficulties that would have to be met in mountainous regions such as we find in Pennsylvania, Virginia, and elsewhere, where they are working against a pressure of 175 to 275 pounds, where the city is built on seven hills, or where one, two or three different services are being furnished. So it is a subject after all for analysis and depending upon local conditions.

It is the speaker's belief that when everything is charged up with all fairness any municipality charges its consumers more than a

private water works, i.e., if the books are kept correctly. If the speaker owned all the private water works in this country he would offer every one of them for sale if any one would pay him a fair price for them, and he would not attempt to dicker on price, but would allow three disinterested parties to name the price and he would cheerfully accept it.

MR. V. A. THOMPSON: The speaker has not had a chance to rub up against water works men very much, being located in Phoenix, Arizona, a long distance from this place, but he has found after careful investigation that if municipalities would collect a fair price for hydrant rentals, for water supplied to public buildings and for street sprinkling, the revenue derived from these sources would easily meet all the expenses connected with lawyer's fees, taxes and rents that private corporations have to pay, besides providing a fund sufficient to cover an annual depreciation charge of 2 per cent.

MR. H. E. KEELER: The speaker would like to inquire the population of Auburn, New York?

MR. J. WALTER ACKERMAN: About 30,000.

MR. H. E. KEELER: Do we understand that your revenue there is $6 per capita? That would be $180,000 revenue; is that correct?

MR. J. WALTER ACKERMAN: Not entirely, no. We have some suburban residences that are outside of the municipality.

MR. H. E. KEELER: We do not care where the revenue comes from, whether from suburban or city property, but does the water works of Auburn, New York, have a revenue of $180,000?

MR. J. WALTER ACKERMAN: No; it does not.

MR. H. E. KEELER: The speaker is glad to understand the matter correctly. The impression he got from the remarks made by the gentleman was that the city of Auburn in its water department in arriving at the cost of furnishing water to its consumers and by reason among others of a revenue of $6 per capita enabled them to and that they did figure an allowance for depreciation. Evidently the gentleman's statement of revenue was not quite correct.

The speaker noticed one thing in Mr. Chester's remarks, which struck him as the keynote of the whole situation, and that was that the capital necessarily invested in a water supply, whether under what is known as a private water company or a municipal water department, represents the investment of somebody's money. In the private company, it is the money of private individuals as stockholders. In the municipal department, it is the people's money as represented and controlled through the properly constituted authorities. In each case, the same items enter into the question of how the charge shall be made for the service rendered and it necessarily follows that the same principles must or at least should be applied in arriving at what would constitute the cost, and that necessarily would mean that in addition to the allowance to cover the cost of operating the plant, which of course includes salaries, supplies of every description, etc., also a reasonable return on the capital invested, an allowance for taxes, depreciation and maintenance of the property in its entirety. In each case the earnings are or should be identically the same, and the consideration which should be taken of all the questions that enter into the case should be the same in both instances.

These necessary items having been all considered, it is easy to determine exactly what can be done in operating such a property. In this discussion the item of depreciation and how it should be arrived at is the only question before us. All of these necessary conditions being carefully considered, it would seem as if the cost of service per consumer could be easily arrived at and should be the same, regardless of the form of management, whether municipally or privately operated.

Mr. Alexander Potter: If the speaker understood Mr. Ackerman correctly, he stated that the revenue per capita in Auburn, New York, is $6. This seems to the speaker to be excessive. In a recent water works case with which he was identified, the income of less than $4 was found upon investigation to be excessive, and he understands that there are certain operating companies whose gross income is less than $3 per capita, which are still making a handsome profit upon their investment.

The speaker would, therefore, like to inquire from representatives of water companies or municipal plants who may be present, what they consider to be a fair rate per capita under varying conditions of service. Of course what would be a fair rate in one city, would not be a fair rate in another city under different conditions. The com-

parison of rates charged by water companies with those charged by municipally owned plants is difficult to make, for municipal bookkeeping is not always what it should be, and on the other hand it is difficult to secure information from private water works companies as to their total income or income per capita, because they believe that this information is part of their stock in trade.

It is to be hoped that Mr. Ackerman will give the association more detailed information in reference to the accounts of the Auburn water works, especially in reference to the amount which he states is set aside year by year for depreciation. A charge of $6 per capita seems so relatively high that it naturally raises the question as to whether it is proper to take from the people sums so greatly in excess of the needs of the particular department for which the money is raised.

PRESIDENT GWINN: The question is not one of rates, but it is revenue of $6 per capita. Did you mean to say per capita, or per consumer?

MR. J. WALTER ACKERMAN: Per capita.

MR. H. B. MORGAN: Six dollars per capita is about 50 per cent higher than it is in Peoria, and we furnish as much free water as any city owned plant.

MR. T. J. POWELL: The speaker is very much interested in this question of depreciation. He has run against it down in his town in Texas. We had a fire that burned up one of our plants about a year ago, and in figuring up the loss on that plant figured in about 28 per cent depreciation of the plant. The reason of this is that in this plant we were drawing water out of wells in which in the rainy season the lift was about 100 feet, but in the dry season had to get down to 250 feet, and the compressors were working at high tension, 175 pounds. When the plant burned down, as it had been in use about five or six years we figured 28 per cent depreciation. On the other hand we made a contract about a year ago with a light and power company and got current from them on a basis of 1.2 cents per kilowatt, and they figured 15 to 20 per cent per annum on their plant. So that this question of depreciation the speaker thinks is something that we do not know anything about. He does not believe that this convention or any convention can establish any positive rules for depreciation, because in one place it is more than in another. A man

in a hilly country might have to carry 90 pounds pressure, where another man in a flat country will have 40 or 50 pounds. It will cost the man in the hilly country more to pump the water and there would be more wear on the engines than in the other case. The only way we can settle this is to fix upon the proper percentage as accurately as we can with the assistance of an expert from time to time who will place a value upon the depreciation in our plant. The speaker does not see how you can do it otherwise. We generally estimate the 2 per cent, but we are not making any money, and do not see how any private plants can make money in our section.

The only thing is to have the distribution system first just as near perfect as you can, and when you get in trouble let some one with more experience than you have come in and tell you the depreciation on the plant.

The speaker agrees with his friend from Louisville that municipal plants ought to sell at a figure that will not involve any profit and as near cost as possible. We are not there for the purpose of making money, but for the purpose of serving the public. We do not think it is fair for the man that uses a large amount of water to get a better rate than the other fellow who uses less. We do not stand for that in our town.

Mr. H. B. Morgan: Can you buy sugar by the pound at the same price that you can buy it by the barrel?

Mr. T. J. Powell: The speaker does not believe that you should discriminate against the little fellow. If the speaker should do that he would think that he was violating his oath of office. He does not believe that you have the right to sell one man any cheaper than the other in a municipal plant, because it is not operating for profit. He may be wrong in that, but that is his belief.

To get back to depreciation, the speaker cannot tell and he does not think anybody in his city can tell what the depreciation on his plant is. For instance, we have electrically operated pumps in one of the plants, and the depreciation on those pumps is more than on the slow moving pumps that we have in the main pumping station. We have another one 4 miles away in which the depreciation is very large, whereas in the first one it is scarcely perceptible at all. The degree of skill in the management of a plant is another factor that has largely to do with the percentage of depreciation. Two years ago when the speaker went there the depreciation was much larger than it is today.

So it comes back to the question of management after all. You can make a bookkeeping charge of 2 per cent for depreciation, when it may be 8 per cent or 10 per cent, or it might not be 1 per cent. The speaker does not see how you can say that it is a certain percentage in every plant, because local conditions must govern.

Acting President Gwinn: Mr. Powell struck the keynote when he said that he did not see how private plants made any money at all. If many of the private water companies of the United States knew what their actual cost of production was they would find that they were running at a loss instead of a profit. The speaker thinks he can say that advisedly—if they really knew what the cost was, if they charged up the proper amount for depreciation, he is sure they would find they were coming out of the little end of the horn. He bought a pair of shoes the other day, and that pair of shoes started depreciating the very day that he put them on. He has not set anything aside yet for depreciation but the time is coming when he will need another pair, he may have to get them half-soled. If he does it should be charged to operating expense. That is just a case of ordinary repair; but the cost of replacing should be charged to depreciation.

Depreciation in the water works business starts as soon as you start your first pump working. You cannot get away from that; you cannot ignore it. It reminds me of the story of the old farmer who went to a show and saw a giraffe for the first time. He walked all around it, looked it over carefully, and then said, "I don't believe it; there ain't no such animal." There are some people who think there is no such thing as depreciation, but there is, and it stays with us all the time. In the speaker's home town we set aside 1 per cent for depreciation each year, and we set it aside in actual cash, not as a bookkeeping arrangement. As Mr. Alvord said, if you do not set aside the money you will not get anywhere. You should earn enough money for depreciation as well as for operating and interest. You should not only earn it, but you should put it back into your property. We charge improvements, extensions, betterments, meters and all construction, to capital account. At the end of the year we deduct from that account the amount of our depreciation fund, whatever it may be. This is deducted from the total amount that is spent for improvements, and we take out bonds for 90 per cent of the balance. The idea is that the money must go back into the plant to take care of the depreciation which has occurred during the preceding twelve months. We put the money from the depreciation fund into the

plant to make up for that which has disappeared during the year. It has disappeared, it has gone somewhere. You may be sure that your plant has been reduced during the year through depreciation. When Mr. Powers, the chief statistician of the United States Census Department addressed the convention in Washington a few years ago, he made a strong plea in favor of setting aside a certain amount for depreciation. He said that it was important that this should be done, that the amount should be carefully determined and set aside, and that 2 per cent on the value of the plant would be a fair amount for depreciation.

The speaker ventures to say that there are not many water plants in the smaller cities that are earning a dividend after paying operating expense, depreciation, interest and taxes.

MR. H. B. MORGAN: The speaker thinks if the gentleman from Texas will stop a moment to consider he will come to the conclusion that he is making a mistake similar to the one made by the old farmer who, while breaking a yoke of steers that he held by a rope, having occasion to use both hands in letting down a pair of bars, fetched the rope a turn around one of his legs. Just at that instant something frightened the steers and the unfortunate man was tripped up and snaked off, feet first, on a wild, erratic excursion, over rough ground, a mile or so before the rope broke and left him in a very lamentable condition.

His neighbors ran to him and gathered him up and laid him together, and waited around for him to come to. When he did, one of them inquired of him how he came to do such a fool thing as to tie the rope around his leg under such circumstances. "Waal," he said, "we hadn't gone five rods 'fore I see my mistake."

MR. W. F. WILCOX: The speaker is in a peculiar situation, he neither owns a plant nor does he operate a municipal plant, he has only three consumers who use 25,000,000 gallons a day, but he is very much interested. He thinks that the main opposition to the depreciation fund from the municipal man comes in this way. The municipal man has hold of a plant that possibly the city has just bought and the value of which has been appraised. That plant has a going value attached to it. That going value as we all know is capitalized on future earnings, and if the proposition of depreciation is admitted it will look bad in the face of the promises the politicians have made as to the economy of taking over the plant, and hence the opposition to

the depreciation fund. In our discussion we have drifted to the big plants. The big plant is as far from a small plant as the moon is from the sun. I think the convention should invite some of the gentlemen from the small towns of about 10,000 population to tell what they know about this. When we get above 100,000 population under proper management we can make money out of the plant; but the speaker recalls right now but few private plants in cities larger than 100,000. They are certainly very few and those that there are are on different basis. It seems to him that this depreciation question ought to be considered by classes on a basis of population.

Let us consider the question of depreciation in towns of less than 25,000 people, and compare cities of from 25,000 to 50,000 and then cities of 50,000 to 100,000, and then cities of over 100,000 and the speaker believes the latter should be on entirely different basis.

MR. ALEXANDER POTTER: On the question of depreciation the speaker thinks there can be no difference of opinion as to the wisdom of creating a depreciation fund; but he is in thorough accord with the gentleman from Cleveland in his statement that there can be no general law or rule laid down which will be applicable to every case irrespective of local conditions. The amount of depreciation must be determined upon a different basis in each particular case. In an appraisement made several years ago the question of the present value of the standpipe was raised. According to the commonly accepted theory of depreciation, the value of the standpipe at that time was practically nil, yet, on examining the steel in the standpipe, it was found to be in almost as good a state of preservation as when first erected. On the other hand, on account of an error in locating the standpipe when the plant was first constructed, it was in reality valueless to the system. This, of course, is a coincidence which might not occur again in many years, and general rules of depreciation must not be laid down upon the assumption that the plant was originally designed improperly.

In another recent case of examination of a plant built in 1877, sections of pipe were taken up throughout the congested part of the city and found to be in almost perfect condition. This pipe was the old class *A* pipe—the lightest pipe made at the time. Certain changes are contemplated in this system which will exert an increased static pressure of some fifteen or twenty pounds upon the system. In order to determine whether or not this old pipe was in such condition that it could be used as a part of the new system, a pressure test of 160

pounds was made. As a result of this test we concluded that the pipe was good enough to be used indefinitely under the new conditions. Another interesting feature of the pipe examined was that, while it was first laid in 1877, it had been taken up and relaid on different streets in 1888, the extra handling, of course, not impairing the pipe in any way. The entire test, which included pipes of 12-inch, 10-inch, 8-inch, 6-inch and 4-inch diameter, was conducted without a single break.

If 2 per cent per annum—the figure stated today as being a fair average for depreciation—had been computed against the value of this pipe, an entirely erroneous idea of its present value would have been formed. The speaker therefore repeats that he is in thorough accord with the gentleman from Cleveland, that each case must be considered on its own basis, and not according to any general law laid down which would fix a certain percentage to be applied to all cases irrespective of the conditions under which the plant was constructed.

QUESTION BOX

Is municipal ownership a success?

Mobile, Ala. Considers it a success.

Bradford, Pa. Yes.

Berlin, Canada. Yes, if properly managed by the board and superintendent. This plant was purchased from the water works company in 1908 for $102,000, bond issue of $126,000 for purchase and improvements. Since that date the debt has been reduced to $85,465.42. After writing off $31,675 for depreciation, we show a balance of assets over liabilities of $141,642.16. During this time the water rates to private consumers have been reduced over 50 per cent.

Buffalo, N. Y. This city is cited as a horrible example in the wasting of water. We have, however, about the lowest rate, both flat and meter, in the country, and always have had. After forty-four years of municipal ownership, our plant has cost over $13,000,000, and our bonded indebtedness is $7,000,000, the plant having been operated and maintained and $6,000,000 paid for extentions and improvements. Is not that proof of successful ownership?

Do street car companies do any street sprinkling in your city? If so, from what source do they procure their supply of water, and, if furnished by the water department or company, how is it supplied, and what charge is made?

Mr. Theodore A. Leisen: In Louisville the street car companies do sprinkle the streets over which their tracks run. The water is furnished them free as being a benefit to the city rather than to the railway company. They take their supply from subway hydrants under the tracks, and they have special cars which are loaded up without stopping the regular traffic of the line as a rule. These cars are equipped with long arm sprinklers that reach to the curb on either side and operate on a swivel joint, sprinkling the street from curb to curb.

Mr. Alexander Potter: What amount of water is used per day during the sprinkling season?

Mr. Theodore A. Leisen: No record is kept as to the amount used on the streets. The sprinkling water used in the city during hot dry spells will run up as high as 5,000,000 to 6,000,000 gallons. We arrive at that by noting the pumpage during an extremely dry period as compared with the pumpage on a rainy day immediately following, and we find that it would drop 5,000,000 or 6,000,000 gallons in the latter case, so that the natural conclusion is that that amount is used for sprinkling lawns and streets. We are not at the present time putting in meters on these sprinkling hydrants.

Mr. Alexander Potter: Will you state what percentage that 5,000,000 or 6,000,000 gallons is of the total supply?

Mr. Theodore A. Leisen: 5,000,000 or 6,000,000 gallons would be about 22 or 26 per cent of our total consumption, which was last year 23,000,000 gallons average per day, running up to 28,000,000 or 30,000,000 gallons during the hot summer months.

Mr. Alexander Potter: The sprinkling takes place during how many hours of the day?

Mr. Theodore A. Leisen: All hours practically from early morning until sometimes late at night, because in addition to the sprinkling they use flushing wagons for the streets, and the flushing is done until after midnight. The sprinkling is done say ten hours a day on an average during the summer months.

Mr. Beekman C. Little: Is the cost of trolley car sprinkling in Louisville borne by the trolley car company or does the city have to pay the car company a certain amount for having this work done?

Mr. Theodore A. Leisen: That is borne by the street car company; that is, they do the work, and the city furnishes the water free.

Mr. Henry L. Lyon: At Buffalo, N. Y., the street car companies are compelled to sprinkle in the business streets through which

they pass. They pay for water 20 cents per season per 100 lineal feet of street sprinkled.

Is the purchase of coal by B.t.u. preferable to purchase by weight, etc.?

Mobile, Ala. The purchase of coal by analysis, on basis of B.t.u., ash, sulphur, etc., has been deemed preferable to purchase by weight; but, as this method is only about two years old, it is difficult, as yet, to make comparison of its actual value.

Buffalo, N. Y. We have purchased coal on a B.t.u. basis for several years and are satisfied that we get better coal at less price than we did purchasing by weight only. A bomb calorimeter outfit will cost about $150 and anyone with reasonable intelligence can learn to use it within an hour or two.

Is it considered practicable to use an incineration plant in connection with steam power pumping station for the disposal of garbage?

Mr. Theodore A. Leisen: The question of garbage or refuse destructor was taken up by the speaker in connection with the board of public works of the city of Louisville about two or three years ago; the object in view at that time being to endeavor to get refuse destructors built in the city, and he stated to the board that if all the steam that could be derived from the refuse was sufficient we could operate a plant very similar to the one which has just been installed at the river pumping station by utilizing an electric motor instead of a steam turbine for driving the centrifugal pump. It was understood at that time that they could generate about 1000 to 1200 h.p. for operating the motor, running continuously for six days each week and shut down on Sunday so as to attend to the necessary repairs and cleaning. That would have provided just about the required power to pump 30,000,000 gallons a day, which would be about equivalent to our total weekly supply; and it was agreed informally between the Board of Public Works and the speaker —it was not between the water board and them officially—that we could afford to pay them for the amount of steam or current which they would deliver to the pumping station, an amount equivalent

to our present cost of fuel. The thing unquestionably would have worked out satisfactorily, but the authorities who had that particular matter under consideration dropped it temporarily, and nothing has been done about it since.

Mr. W. Z. Smith: How much garbage was it estimated would be necessary to get 1200 h.p. on the shaft?

Mr. Theodore A. Leisen: The speaker never attempts to remember figures, and regrets that he has not any of that data here. He did not see these questions until a few minutes ago and did not know the subject was coming up. The speaker has the data at his office and will be glad to take the matter up with you if he can find the time to look it up but as the question has been dormant for over two years he has no recollection whatever of the figures.

Mr. W. Z. Smith: A proposition is being considered by council at Atlanta, Georgia, from a destructor company. They propose to install a plant capable of incinerating 250 tons of garbage per day, and from that to produce steam power sufficient to generate 1500 kw. electricity and transmit it 6 miles to our river pumping station, and there by motor-driven pumps to pump from 18,000,000 to 20,000,000 gallons of water per day against a head of 254 feet. The speaker is seeking information on this matter; which is being handled entirely by council. He has not had an opportunity yet to even go into this proposition, and if there is any one present who has had any experience in pumping water by power developed by garbage disposal plants he would like to hear from him.

Mr. Theodore A. Leisen: The speaker might for Mr. Smith's information state that he can probably get a good deal of information from Milwaukee on that question, they having recently installed a refuse destructor plant.

Mr. Rudolph Hering, of the firm of Hering and Gregory, New York, made a report to the board of public works of the city of Louisville on the proposed destructor plant. He was called in when the question was up here and reported in regard to the general feasibility of the proposition. Of course the whole question is whether you can get the power. If you can, you can pump the water. In our city it could be properly utilized to very good advantage, because we can pump six days and shut down the seventh as we pump into

a reservoir. If it were to be employed for direct pumping the speaker questions whether it would offer the same degree of efficiency or satisfaction.

Mr. W. Z. Smith: We have a reservoir in our case, and we thought of having a flexible unit of three pumps, so that if there was not sufficient garbage to produce power to drive all three of them at once, we could use two, or even one pump.

Mr. Andrew Rinker: They have recently installed in Minneapolis an electric light plant in connection with their garbage incinerator. That has been in operation only a very short time and there has not been any definite detail as to maintenance and expense account; but they are furnishing 150 street are lights by the disposal of about 125 to 150 tons of garbage per day. It is a night load. They are utilizing this power for only about eleven hours a day. We would be glad to give you further information and will be able to do so very soon, the plant having been just placed in operation.

Mr. M. N. Baker: It is very important to go into this matter with extreme care as an engineering proposition, and to work out very carefully the cost of obtaining power from garbage as compared with obtaining power from coal or any other available means. Refuse destructors have been used for power production purposes in England and on the continent of Europe for many years with apparent success; but unfortunately few statistics giving detailed operating costs and revenues are available.

The gentleman from Minneapolis states that they are supplying so many lights from burning so many tons of refuse; but what has it cost to install that power plant, and what would it cost to install a power plant which would do the same amount of work with other sources of power?

Proposals to utilize garbage have a certain glamour about them because they appear to be offering an opportunity to get something for nothing, which is always attractive; but every case is an engineering proposition that should be worked out in detail just like any other engineering proposition. There are a great variety of local factors involved. If you start to build a garbage incineration plant which will be suitable for the production of power, you have to first find a proper location for the plant. You have to haul the

garbage a greater or lesser distance to get it to the plant, and if your alternative is to treat the garbage by a reduction system, which will yield grease and fertilizing material, you will perhaps have to locate that plant—for reasons which I will not go into—at an entirely different point, and therefore your cost of hauling will be greater. Should you adopt some other method of disposal your haulage cost will be still different. You must take into account the location of the plant, the length of haul, the method by which you will convey the stuff, whether by wagons or on railroad cars, or whether it is possible to use the street railway system. When you have got it all figured out as to what it is going to cost you, and then compare the results obtained with the cost of producing electric light from coal or from water power, you may be surprised at what you find. That is what happened at Toronto a little while ago, when Hering and Fuller worked up a very interesting report. They were not proposing to pump water, but the principle involved is exactly the same. They were engaged to make plans and estimates for a refuse incineration plant, on the supposition that they could utilize the heat for electrical purposes; but they found out that they had better let all that steam go to waste rather than to install the necessary plant to generate electricity, because of the low price of hydro-electric current at Toronto.

Local conditions that should be given careful consideration enter into every case and demand the attention of an engineer who has had experience.

Most of our American cities consider garbage disposal as a mere matter of getting rid of unclean swill, and assume that any council committee can handle the matter. The engineer has got to be called in to handle these questions, and any water works man who is not experienced in that line of engineering had better go slowly and carefully before he commits himself to a proposition which is going perhaps to make him a whole lot of trouble and cost the city a great deal of money. It may be worked out, and it may be done economically under the guidance of a careful engineer who is competent to advise and who is familiar with the subject.

Mr. William Hooker: The speaker is on the committee, to whom the Minneapolis Crematory Plant is assigned. The original cost of the plant was $64,000. The plant disposes of 120 tons of garbage per day, collected at a cost of $1 per ton by thirty teams. The wagons carry large metal tanks which are removed at a cer-

tain point on the street car line to flat cars and taken to the crematory plant located on the edge of the city, on what we know there as the Workhouse Grounds, comprising about 100 acres.

Our original intention was to burn garbage and the question of the utilization of the power generated by the incineration of garbage has only been before us six months. There was a waste of 200 h.p. and it was decided by our committee of health and hospitals to install a power plant at a cost of about $50,000. It has just been completed at a cost of $48,000. It started up permanently the Saturday night that the speaker left home. We tried it in the tenth ward, with 200 arc lights of 6.6 amperes with good results thus far.

The garbage is collected separately from the ashes. Each housewife is supposed to wrap the garbage up in paper and deposit it in a 30-gallon can placed at the rear of the lot where it is collected on certain days of the week.

Mr. Alexander Potter: Mr. Baker has very well said that this is a matter that requires the very close attention of an engineer. The speaker has not heard a recent report from Milwaukee where they propose to utilize steam from refuse obtained in this way, and where he understands in order to utilize that steam it cost them approximately $1.50 a ton to reduce the garbage. With a straight incinerator plant properly built, such as you have in Minneapolis and other towns you can reduce garbage at a cost of 50 cents a ton.

The utilization of that garbage to produce steam introduces another very important factor, and that is that it is necessary to carry the garbage to one central point for economical reduction. One of the greatest costs in garbage disposal is that of collection; and if we ignore the steam producing qualities of the garbage we can build in a city a number of garbage plants at different places to reduce the haul by cutting it down by four, when the cost of hauling the garbage will average perhaps three times what it cost to reduce the garbage; and therefore we see that in determining the cost of this power there must be deducted the additional cost of hauling to this central station. So that it is a very broad subject. As Mr. Baker well says, it is an attractive proposition because it seems to be getting something for nothing; but any city that undertakes such a matter should first thoroughly investigate it from all view points.

Mr. Theodore A. Leisen: In justice to himself, after what Mr. Baker said, the speaker wants to say that this matter was not

brought up before the city authorities at his instigation. They had the matter up and had taken into serious consideration the question of some method of disposing of the city refuse. After deliberating for some time they finally concluded that the destructor plant which would handle all the refuse, including ashes and garbage, was the most feasible for their purpose.

Our position in the matter was simply that of accepting from them the power which they could produce providing they could produce enough; and we were to pay for that power the equivalent cost of our coal. So that as far as the water company was concerned, we were in a fairly safe position. That covered the speaker's responsibility in the matter.

The speaker might say one word further: The general scheme outlined here was to have four different stations distributed throughout the city, and then convey the power in the form of electric current to a common central point. He believes that the authorities in charge of the matter concluded that the haul in that way would not be any longer than it is at present. It is rather difficult to dispose of ashes, etc., in certain sections of this city, the haul being necessarily long and the proposed location of these plants did not increase the haul, and therefore would not have increased the cost. On the other hand, by carrying all the refuse in one series of wagons it would probably tend to decrease that cost slightly.

Another point which was brought out at that time was the question of sanitation and how the city would be affected by reason of the construction of the destructors. At present the socalled ashes, containing large quantities of vegetable and other putrescible matter, are dumped in the lower places around the city, and it is generally considered that that is not the most desirable way of disposing of this material, so all of these points were considered here at that time.

Mr. F. H. Shaw: The speaker would like to ask the gentleman from Minneapolis what the cost to the city is for furnishing arc lights. What does the city save by lighting with electricity derived from the incineration plant?

Mr. William Hooker: For arc lights of 6.6 amperes the General Electric Company has charged us $65. If our calculations hold good we expect the cost to the city under the new method will not exceed $50 each.

PRESIDENT GWINN: You would not get the same amount of garbage in the winter time?

MR. WILLIAM HOOKER: Very nearly the same amount in the winter.

PRESIDENT GWINN: In your case it is simply the utilization of waste heat which would otherwise disappear without return?

MR. WILLIAM HOOKER: Yes, sir. We had an average waste of 200 h.p. per day. The head of our health department, Dr. Hall, took the matter up with the best means at his command, and verified that statement.

MR. E. H. FOSTER (by letter): The practice of utilizing the heat produced by the incineration of city refuse is one which is bound to become more and more prominent before water works engineers of this country.

The general refuse from a city, such as is collected by scavengers, may be divided into three general classes:

Garbage, which is the output from kitchens and hotels, consisting chiefly of animal and vegetable matter discarded in the preparation of food.

Rubbish, consisting of various discarded articles from the house, such as old furniture, old carpets, old clothes, newspaper wrappings, bottles, tins, etc.

Ashes, from fires used in cooking or house heating.

Of these three very different classes the garbage contains the most moisture, even as high as 80 per cent by weight. Rubbish is quite inflammable and high in heat units, and usually with very little moisture content. Ashes, on the other hand, are generally dry and contain from 20 per cent to 25 per cent of unutilized carbon. Either of these classes alone is difficult to collect and dispose of, but mixed together they are very easily handled, both as to collection and to disposal by incineration.

Within recent years a form of furnace, known as a destructor, has been developed, chiefly in England and only lately introduced into this country. Good examples have been installed and put in operation in American cities during the past five or six years at New York City, Buffalo, Milwaukee, Montgomery, Alabama, Seattle and San Francisco, and in Canada at Westmount, Vancouver, Ottawa, Moose Jaw and Calgary.

It has been found that the easiest and most expeditious way of handling the waste from the city is to permit the householder to mix it, as they naturally would if one receptacle be used, and arrange for the collectors to deliver it to a centrally located incinerating plant. When the burning is carried on at a high temperature, never allowing the gases leaving the furnace to fall below a temperature of 1250° F., the plants are operated entirly free from odors or nuisance of any sort, and experience has proven that no additional fuel other than that found in the material itself is required. When combustion has been completed, the waste gases contain an abundance of heat units which may be utilized by installing steam boilers to absorb this heat. An evaporation of from one to two tons of water into steam at a boiler pressure of 150 pounds or more, as desired, may be obtained per ton of mixed refuse consumed. When it is considered that the average city will be able to deliver approximately one ton of mixed refuse per day per thousand population, it is readily seen that a very considerable by-product in the nature of steam to operate a pumping plant is available where the modern system of disposal of refuse by incineration is installed. It is only by utilizing this steam in some such manner that an incinerating plant can be operated up to its full economical basis. Usually there will be just about enough power in a refuse incinerator to operate the water works pumping plant, but it will probably always be necessary to provide an auxiliary boiler to be sure of furnishing sufficient steam at times when the refuse collection may be deficient or may be interrupted altogether by holidays or for other causes.

This practice, though new in this country, has been in vogue for many years in England, where several very successful installations may be seen. The steam produced by such an incinerating plant might be utilized for driving steam electro generators, and the current utilized for lighting or for power, but the quantity is not usually sufficient to justify a wiring system, unless it be for the special purpose of conducting the power to a more convenient point for its utilization; for instance, to an outlying pumping station where the pumps may be driven by electric motors. Not only is it entirely practicable to use incinerating plants to drive steam power pumping stations, but the economy to a city of thus utilizing its own power is so evident that the practice is bound to gain a very strong foothold in this country, and the officials would do well to give this subject their very careful and interested attention.

What action do you take, at time of fire, to regulate or control large private fire services, after the fire department is in service at the fire?

Bradford, Pa. Has automatic service.

Mobile, Ala. No special action taken.

Buffalo, N. Y. Has a man attend all fires in winter, to shut off private fire lines if necessary, and to attend to public fire hydrants after the fire. In warm weather the fire department is relied upon to notify the water department if it is necessary to shut off any supplies.

Hoquiam, Wash. Makes it a practice to locate water pipe lines for large fire services with a shut-off near the water main, and in case of fire to have a man get to the shut-off as soon as possible to shut it off if advisable.

Elyria, O. Takes no action.

Toledo, O. Shuts off street valve controlling sprinkler system, if the fire department requests it.

Stratford, Ontario. Takes no action.

Streator, Ill. Places a man at the valve controlling the private fire lines.

East Las Vegas, N. M. Has very few large private fire services, but is increasing the number and appreciates the necessity for controlling them. No measures have heretofore been taken, but they are now locating the valves so that they can be shut off during fire if necessary.

Tampa, Fla. Has no large services, as, under the decision of the Florida Supreme Court, which held the water company liable for loss by fire in case of any deficiency of pressure or supply, they have evaded making any large connections for purpose of furnishing fire services.

Quincy, Ill. Reserves the right to close the valves controlling large private fire services during fires if it appears that the public fire service is in danger of being crippled.

El Paso, Tex. Cuts off private fire line when fire department is working, if private fire line is not being used on the fire.

Spokane, Wash. Repair man reports at all fires that seem dangerous.

Dubuque, Ia. Has man with key at fires in buildings equipped with automatic sprinklers, but does not shut off unless falling walls break the connection.

Sault Ste. Marie, Ontario. Has had no occasion to control private fire services.

New Orleans, La. Has water department man attend large fires with valve key.

Lake Charles, La. Rates are made with understanding that no water is to be used, and there is no occasion to do anything.

Altoona, Pa. Shuts off valve in line leading to building.

Richmond, Ind. Has had no serious fires on property of consumers having sprinkler system. All valves on fire lines are placed as close to the mains as possible, and, in case the sprinkler system does not extinguish the fire, water can be turned off the sprinkler service.

Rahway, N. J. Has only one large private fire line, a 6-inch controlled by a detector meter and a shut-off valve located 90 feet from the building. Would shut off water if found necessary.

Have you had any experience with crippling of fire service, owing to breakage of large private fire services, caused by the falling of the building or other result of the fire?

Altoona, Pa. We have had only one experience of this kind, and as soon as we could get at the valves, we shut them off.

Berlin, Canada. No.

Bradford, Pa. No.

Buffalo, N. Y. No.

Dubuque, Ia. We are prepared to close outside valves as soon as falling walls break pipes in building, thereby saving the pressure for fire engines.

East Las Vegas, N. M. No.

El Paso, Texas. No.

Elyria, O. No.

Hoquiam, Wash. Have always been able to cut off supply and have never had fire service crippled by reason of breakage of fire services.

Mobile, Ala. No.

Monessen, Pa. None.

New Orleans, La. Not yet. Believe 4-inch limit should be set on size on account of this danger.

North Attleboro, Mass. None.

Quincy, Ill. None.

Rahway, N. J. No.

Richmond, Ind. No.

Spokane, Wash. During a recent lumber plant fire, a mill on an adjacent lot took water from its private fire protection service to protect its own property. This crippled the supply to the fire department, owing to the then inadequate size of the street main supplying both establishments.

Stratford, Ont. No.

Streator, Ill. No.

Toledo, O. No.

Mr. Morris R. Sherrerd: The speaker would like to say a word on that point. We are continually running against insurance companies on the question of the size of fire service mains to be laid. It has been the speaker's judgment that the size of the mains should be limited, and our practice has been to so limit them to 6 inches, not to allow larger fire services than 6 inches, and not to allow two in the same part of the cellar; that is, we will allow two or more 6-inch service connections if they enter the building in the cellar where separated by a fire wall, in order to prevent the crippling of the main supply in case of walls falling and breaking the fire service supply.

Our custom has been on the high pressure system to charge $150 a year for 6-inch services, and $100 a year for 4-inch services, having in view the maintenance of an inspection department to look after the surreptitious use of water from such services, and also to maintain a force of men who respond on every second alarm of fire to handle this very question which is asked here, as to what action is taken at the time of the fire to regulate or control large private fire services, after the fire department is in service at the fire. We also make it a condition of the application that the applicant who signs the same shall enter into a special contract which relieves the water department from responsibility, and also gives us the right to shut off in case the fire service is being used or abused in such a way as to affect the general protection of the surrounding property.

The question has lately been raised as to whether this is a proper charge or not. The insurance people are asking for a reduction, in fact practically asking that the charge be entirely wiped out. That is one reason why the speaker thinks it might be well to discuss the matter at this convention, because a uniform policy on the

part of water departments should be adopted. There seems to be an inclination on the part of the insurance companies to agitate the question among their patrons and to suggest that such service ought to be given practically for nothing. We have recently adopted the rule that the department will give this service gratis if the user installs a meter at his own expense. This is the only concession which so far has been given. But it seems to the speaker that where a department is giving special service of this kind, which is certainly one which might cause interruptions or deficiency in the ordinary supply, such particular special privilege ought to be paid for in some way which would give the water department sufficient funds to cover the expense of inspection and supervision. This will cost considerable and for it an adequate charge should be made.

Mr. William R. Young: This goes back into the very subject of charges for fire protection, a matter which comes up every year. The speaker would like to hear a great deal of discussion upon it, and would like to speak of a little experience we have had in regard to the handling of this matter, and the matter of protecting the department in case of large fires.

Six or seven years ago our department had a great deal of argument with the underwriters in regard to automatic sprinklers and fire protection. After a strenuous effort on our part we were able to overcome very many of our difficulties by inserting detector meters. The only consideration we asked for was, that we establish at the curb a post indicator of ornamental design 30 inches in height, on each 6-inch service installed in the city; because if a building is not saved in the course of the first fifteen minutes of a fire it is often impossible for the fire department to turn off the service because they cannot get to it by reason of the fire, and also because in our northern climate where the streets are covered with ice and snow about five months in the year, it would often happen at the time of a fire that it would be almost impossible to find the connection. This difficulty would be obviated by the use of a post indicator. The National Board of Fire Underwriters has recommended in a number of cities this device. We have had it and it has worked very nicely, and by means of it we have been able to turn off several 6-inch connections during fires, where the services were not needed.

Mr. J. N. Chester: The last expedient mentioned, namely the post indicator valve at the curb, is all right provided you do not

have a condition such as existed at Jamestown, N. Y., a few years ago, where the fire instead of being put out by the automatic sprinklers started and gained headway in the end of the building where a 6-inch main entered. Immediately inside of the building the riser of the sprinkler system was located. The fire got well under way and the walls of the building fell out. There was no post indicator, but there was a valve, and it was covered by the falling walls so that it was impossible to get at it, and the whole vicinity was endangered by the inability to shut off that valve. You all know that a full flowing 6-inch main would materially reduce the pressure on other mains in its vicinity. So the speaker would suggest that this valve, whether it is equipped with an indicator or not, be kept far enough from the building that whatever might occur the valve could be shut off.

In a municipal plant the same authority controls both the fire and water departments, and if any friction arises it is adjusted in the council. In a private water works, however, it may not be so easy to adjust matters between the fire department and the water works. In private water works with which we have been connected we have found it a wise expedient when an application is made for a sprinkler connection or a private fire service of a size, say, of two inches and upward, to insert a clause in the contract that such connection should receive the approval of the chief of the fire department. That keeps him in touch with it, and if a new fire chief comes in he is bound by the approval of his predecessor. In the case of Jamestown, the connection had not been approved by the fire department, and they of course condemned the water company for having had such a connection in existence. After each big fire somebody has got to be blamed or be the "goat," and if you can keep your record clean, it is of course a great advantage.

As to what should be charged for these connections, and whether they should be given free of charge, is open to discussion. As a former speaker said, insurance companies object to a charge being made, they want it furnished free because it puts money in their pocket. Private fire protection is always an aid to insurance companies if it is furnished at a low rate or gratis. We believe that a municipality can no more than a private water works company afford to give free fire protection. They may offer free fire protection, or free sprinkler connections, as an inducement for factories to locate in their midst, but that is just the same as voting bonds or giving a bonus.

We have in this body referred many times to the rules of the Wisconsin public service commission, and if any one present has any doubt as to whether or not his city or plant should make a charge for this service, we hope he will read the report of the Wisconsin public service commission which they made on the city of Madison, which is a municipal plant, and the charges that they there put on private and public fire protection; and the speaker believes it will remove any idea that private fire protection should be given free of charge or free connections made. There are a great many of us that are getting into court on the subject of the rate for this service. The speaker may perhaps be getting away from the question which is not so much in regard to the charges for this service as what we do at time of fires, and what experience we have with regard to the crippling of fire services; so he will leave the question of rates except to say that he thinks that there would be a great many more connections made if we did not make a charge. The statement made by one speaker, that they limit the size of connections to 6 inches, is all right if qualified; all wrong if unqualified. We do not believe of course that a city or company should permit a 6-inch connection to a 4 or 6-inch main. The speaker believes the size of the connection should be governed by the size of the mains in that vicinity. He believes it is always best to have two connections instead of one, if you can. If it is a 6-inch main you can give them two 4-inch connections from different streets or at different ends of the building. All you water works men know that the hazard due to these connections is what warrants the charge. The smaller the opening, the smaller the hazard, and therefore the smaller might be the charge; but the charge should be in proportion to the hazard and in proportion to the size of the opening. If the street main was 10 inches or under, larger than a 4-inch connection should not be allowed.

The underwriter or insurance man when he looks over a factory, is going to recommend the largest service that he thinks will be of any benefit at all, and far more generally calls for an 8-inch connection than for a 6-inch; he never calls for a 4-inch. But they will take a 4-inch connection if they cannot get an 8-inch or a 6-inch. They will say they will not and they will leave town and come back. Many times in the speaker's experience underwriters have declared that a particular risk would not be written unless we made a certain connection; but we had a hard and fast rule of 4-inch and no more, and yet have to know of the first case where the insurance com-

panies have finally turned down or refused to write the risk when they were limited to a 4-inch connection. Sometimes they got two 4-inch connections, but generally one—and they did not get that without charge.

The insurance companies' cry for *no charge* for these connections is all right from their standpoint, and the size which they ask for seems proper from their side of the fence, but any water works in allowing large connections is doing an injustice to itself as well as to the citizens of the town by jeopardizing the remainder of the service. You are doing an injustice to the taxpayers when you increase these connections beyond what is sufficient. The insurance representative when he states his claims to a factory man, says that the average number of sprinkler heads that go off in a fire is five, and if more than twenty-five go off the building is going to burn anyhow. Then why provide connections sufficient for five hundred or five thousand sprinkler heads if when only twenty-five of them go off the building is going to burn? These are some of the arguments that you can put up. Their call for a large main is like their call for a large reservoir, they forget all the sanitary principles involved. They will ask for 15,000,000 gallons, when 2,000,000, 3,000,000 or 5,000,000 would do. That is a natural position for them to take. They will ask for what they want, but you have to limit them to what you can consistantly give.

Mr. Wirt J. Wills: The speaker would like to ask for a full consideration and discussion of this matter of proper charge for fire protection services. That is the principal reason he is here now. We have a charge in our city based on the number of sprinkler heads, and our Manufacturers' Association has taken it up and is going to come before us next Monday and argue that this charge should be reduced. There seems to be an idea that there should be no charge at all. So it will certainly be considered as a favor if you gentlemen here will give full expression as to what you do charge. The speaker presumes that everybody does charge something, and that they run water works for remuneration. He would like to ask if there are any gentlemen here who represent cities where there is no charge made for fire protection? He would like to see how many such there are, if any.

Mr. F. H. Shaw: We charge for putting in the service up to the building line, and inspecting it for illegal use of water, making no charge whatever for the use of water. We do not put in a meter.

Mr. M. L. Worrell: At Meridian, Mississippi, we make a charge for fire services at the same rate per hydrant as formerly charged by the private company which we succeeded, namely, $50 for each standard double-nozzle fire hydrant; for a single-nozzle fire hydrant $25 per annum; sprinkler heads 5 cents each, with no annual charge of less than $15, which is the minimum.

At Rome, Georgia, where the speaker was located for three years, they made no charge except, as the last speaker said, for installation of the service. The speaker understands that in Atlanta, and in nearly every city in Georgia, it is the rule to make no charge for fire services. At Selma, Alabama, where he was located a good many years, they make an annual charge of $45 per hydrant. Selma now owns the water plant and makes the same charge for fire service as did the privately owned company.

Mr. W. Z. Smith: Atlanta makes no charge for fire services within the city limits. The only charge made is for making the connection from the main to the property line. However, we do make a charge for fire services for plants located outside of the city limits. Under the law we cannot supply such services outside of the city limits without making a charge, and that charge is based upon the valuation of the property protected, and is as low as we can consistently make it. For plants of a valuation of $50,000, the charge is $12.50 semi-annually; for plants whose valuation is $50,000 to $100,000, the charge is $25 semi-annually. We do not control our fire services by a meter. On the automatic sprinklers the valve to the main line is strapped open by the insurance company, and we make a regular inspection of the line to see that there is no surreptitious use of water. On the fire hydrant and standpipe lines we seal each separate hydrant, and make inspections at irregular intervals when they least expect it. We often put in a bypass with a regular $\frac{5}{8}$-inch meter connection, letting both the insurance companies and the fire department know at the time we are doing it. In this way we can close the valves of the main line and let our inspector stay on the job for half a day or a day, if necessary, so that he will see if there is any flow of water through that main going into the premises. Then we take the meter out, examine the valve and seal it open again. We make no charge for this inspection. The speaker is not defending the practice of making no charge for fire services, and does not think it is right for any property to have the protection of fire services at the expense

of other property owners who are taxed as much in proportion as the owners who have protection.

Mr. John A. Affleck: We make no charge for fire services in Harrisburg, Pa.

Mr. Leonard Bauer: We make no charge for private fire services in Newport, Ky., taking the stand that it is not only property we are protecting, but it is human life. It is just as necessary that a municipality should consider the fact that they are protecting human life as it is that they are protecting property; therefore, we furnish water free but they must pay for the installation of the services.

Mr. E. E. Davis: We make no charge for water used for fire protection, but the property owner where the service is put in pays the cost for the installation and for a meter with a vault sufficiently large on the sidewalk for a man to go down and fix the meter without taking up the street. We have a valve that is usually watched; in fact the fire department has put a badge on me and my assistants, and we respond to all second alarm calls in order that we may shut off the valves where necessary, or open them so that the fire department can hook on their engine or hose. On the sprinkler systems we require a detector meter. On fire protection services where they have a hose system going up the walls, we require them to have a meter. All fire protection connections are metered, but we make no charge for water used for extinguishing fires. The underwriters kick against meters, but they kick in the wrong place when they come to Richmond. We have some connections that are not metered and which were put in before we adopted the rule requiring a meter. Those we charge $25 a year for, because the hydrants are opened and are tested about every six months. We have a law whereby we can extend the main outside of the city, and we charge $50 per annum for such service and they pay all the expenses of installing, and the expense to the city is nothing except that of reading the meter.

The speaker has had a great deal of trouble with councilmen asking him why he required a meter on a fire service when he knew there wasn't going to be any water used. He has told them in reply that he would have to repeat what he said to his superior officer before he became superintendent.

There was a man who had a well from which, he said, he got the water for his boiler. The speaker passed there one day and saw a piece of hose lying on the street, and he sent an inspector there, who asked the man who washed out the boiler where he got his water. He said he "got it from a connection on the corner there." The inspector asked him, "How is your well getting on?" "Oh, we haven't used the well for six months." He had connected the hose to the main. The speaker sent that man a bill for $338 for water consumed, and a request was made that he purchase a meter and put it on there, which he did.

If you do not meter a fire service, gentlemen, the pipe is liable to be tapped and water used for other purposes.

One of the grandest men the speaker thinks that ever came into Richmond, and a man who he knew was honest, found that water was being taken from the fire service in his factory without his knowledge, and he was perfectly astonished when the speaker told him of it. So the speaker says, gentlemen, that all fire services should be metered.

We never give over a 4-inch connection for domestic service, and we always object to making more than one connection for fire service. A man asked why we didn't give him an 8-inch connection for fire service, and we told him the reason was that if we did that other people would not get what they ought to, and that if he did not like that he could put a tank on the top of his house.

Mr. W. J. Wills: This convention has given a great deal of time in the past to the question as to whether meters should be put on fire protection services. The speaker does not want to bring that up again, but will say that we formerly had a rate of $37.50 for fire services and 6 cents apiece for sprinkler heads. Our present minimum is $36 a year, furnishing the fire protection without a meter, as the insurance companies wanted, with a bypass to give them local consumption if they want it. The majority of users were satisfied with this, which is $1.50 less than the former $37.50 rate. But the insurance men, than whom there are no smarter, went to the larger manufacturers and through the Manufacturers' Association they have given notice to the water department which the speaker represents that they are going to make a fight on this matter, because they say that under this ruling some will have to pay more than they did before. Ninety-nine times out of one hundred when fire protection services are not metered, they are

robbed. In order to do away with that we were going to have just one opening and that wired and sealed. We certainly ought to get more money for that service. The speaker hardly sees how some cities can get along without making any charge, and he thinks they will have to do it sooner or later. He thinks that $36 is certainly a fair charge for a 4-inch opening, when the consumer gets a reduction made of 80 per cent in his insurance rate because of that service being supplied. If that rate of $36 is not fair then he wants to know it, and he would like you gentlemen to tell him. The speaker has explained this thing in detail to a great many of the gentlemen here and they all seem to think that it is not too high, but on the contrary, that it is probably not enough.

The meters that we have on fire protection services we furnish ourselves. We tell a man that if he puts on the detector meter that has been referred to here, it will cost him $450 or $250 anyhow. We tried that and they hollered against it larger than the other thing. We want to know if any of you gentlemen can show us where there is any money in furnishing fire protection at less than the rate we are charging. The speaker came here to get this "out of his system." The underwriters are fighting our department under the cover of the Manufacturers' Association of the city of Memphis, and you will all have the same trouble if you have not got it already.

Mr. Alexander Potter: The gentlemen who have spoken representing municipally owned plants, with the exception of Mr. Worrell of Meridian, Mississippi, state that they supply fire services without cost. If it is fair to design a system so as to make provision for this extraordinary draft at isolated concentrated places, why is it not just as fair to relieve the city as a whole from the onus of public fire charges for fire hydrant services? If it is fair for an individual supply, it is equally fair for the city; and the speaker thinks this inquiry is very pertinent because in an investigation which he is now conducting he finds extraordinary differences in fire hydrant rentals as they go over the country, running all the way from $5 per annum up to $50 and $60 per annum under conditions which are somewhat similar. Now that discrepancy is a very serious one. To give these private consumers water free does not merely imply being ready to give them water free, to do which we must increase the size of the pipes and add to the entire cost of the system to the municipality as a whole, but it involves the readiness to serve by giving them water when they need it. Therefore

he thinks that it is a very pertinent inquiry to ask, if water works are giving these connections free why not then eliminate the cost of fire hydrant services altogether, and permit a water company, or permit a city, to charge for the maintenance of the system and distribute that charge amongst all water takers as a whole in proportion to the water that they use?

Mr. A. A. Reimer: We have not many manufacturers in East Orange, but what there are must be of a rather tractable disposition, for we have not had very much trouble with them on this fire service question. We made certain regulations that called for a sealed valve generally on single large connections from which a branch is taken to give them an ordinary service through meters. Some years ago we changed over to the detector meter system, and have equipped fire lines with detector meters; but we charge for that service, and we attempt to keep the same in relation to the size of the plant by unit prices. Our charge is 25 cents per $1000 valuation of the plant and contents. If a man has a small plant he does not pay very much; if he has a large plant, he pays in proportion to the size of it. We have not had very much trouble from any requirements that the underwriters have made. The speaker believes that a unit charge is fair and if the basis of that unit charge is worked out properly, there should be no objection from any one. We do not claim that our system is absolutely right; but it at least approaches some scheme for meeting the difference in the size of the plants.

Now so far as the size of the connections is concerned, the speaker does not seem to be in accord with a number of the speakers who have referred to their systems. We do not put any limit on the size of connections at all. If a man comes in and applies for a connection we give him what he asks for. If he wants a 6-inch connection, we will put it in for him off a 4-inch line. It is not likely that he will ask for more than a 6-inch or a 4-inch. If he asks for an 8-inch connection we give it to him freely. We believe that if a system is designed so that there is an ample supply for say twenty effective fire lines on the hydrant system in your congested districts, that it will not make much difference what size fire line you take into a plant. We put certain restrictions around our fire lines because we have found considerable water passing through detector meters, and passing in such quantities that it would affect the pressure. When that is the case we try to arrange some other scheme

of getting the connections into the property, such as taking them off two different sides of the building, so as to keep up the pressure. We are not troubled very much on that score as yet.

MR. R. L. CLEMMITT: In Baltimore we have a large number of special supplies for fire protection, they are of all classes and kinds, from the most elaborate systems covering such plants as the large properties of the Mt. Vernon-Woodberry Cotton Duck Company, the American Tobacco Company, and the Baltimore and Ohio Railroad Company, down to the simplest form—a standpipe with hose outlets.

Our method of controlling and installing these services is best explained by our very brief regulations covering this class of service, which the speaker will quote:

WATER BOARD REGULATIONS GOVERNING SPECIAL WATER SUPPLIES FOR FIRE PROTECTION

RESOLVED, on this sixteenth day of March, 1905, that *Special Water Supplies for Fire Protection* will be granted by the *Water Board* upon application of the owner or owners of any building or premises, where in the judgment of the *Water Engineer* such special protection may be necessary, upon the following conditions:—

Installation of Service and Charges

All fire services will be installed by the Water Engineer, who will ascertain the best location for same, and lay the pipe from the street main to a point just inside the wall of the building or within the building line of open yards, where buildings are set back from the building line. The owners will be charged with the exact cost of labor and material used in the work of installing the service, with an addition of ten per cent to cover the cost of superintendence and inspection. All repairs to the service pipe between the street main and the building shall be done by the Water Engineer at the expense of the owner.

Size of Service Pipe

In all cases the Water Engineer shall decide the size of the service pipe required, which shall be determined by the size of the street main, available pressure on the main, and

the nature and capacity of the fire protection equipment within the building.

In all cases where underwriters pumps are to be installed, a suction pipe of sufficient internal area to deliver a quantity of water equal to the full rated capacity of the pump will be allowed, and no enlargement of the said suction pipe inside the premises will be permitted. If, however, this service pipe is run to a surge tank placed in close proximity to the pump, the full size of suction which the pump calls for may be run from the pump to the tank.

Number of Services

One service only will be allowed to any one building or premises, unless in the opinion of the Water Engineer more than one is absolutely necessary for the proper protection of the premises. All fire protection equipment connected to the city service shall be confined within the building or on the premises named in the application, and where two or more connections are made for one building or premises, they shall be kept separated, unless special permission is obtained from the Water Engineer to connect the same in a manner to be approved by him.

Use of Fire Service

No water shall be drawn from the fire service pipes for any purpose whatever except for the extinguishment of fire, and no connection shall be made between the fire service pipe system and the regular water supply to the premises, and valves on hose outlets, drain cocks, etc., placed on the pipe system shall be of a style that can be sealed by the Water Department Inspector, and when any such valve or cock is opened, the owner or occupant of the premises shall notify the Water Engineer, so that the same can be resealed at once. This paragraph is not to be construed as prohibiting a reasonable use of water for fire drills, draining of a system to prevent freezing, or other reasonable use in connection with proper fire protection.

Contamination of Water Supply

Any fire protection system supplied with water from the city service shall be supplied exclusively with such water

and no connection will be allowed with any other system drawing its supply from any other source whereby the city water supply may be contaminated by the failure to close valves, or leaking check valves, etc., and no auxiliary or secondary suction pipe to any underwriters pump taking water from the harbor, streams, or other contaminated source will be permitted.

Any fire protection system using water from the harbor, streams, or other source than the city service, shall be kept entirely separate from any such system supplied from the city service.

Inspections

All fire services shall be subject to inspection by the Inspectors of the Water Department, who will visit all premises having fire services from time to time, and the owners or tenants shall give the Inspectors all reasonable facilities for making the inspections, and any information concerning the same that they may require.

Care will always be taken that inspections will be made with as little inconvenience to the owners or occupants as possible.

Penalties

In any case when the owners or occupants of any premises are found to be using water from a fire service for other purposes than fire protection, the water shall be shut off from same, until the offenders shall give reasonable assurance, before the Water Board, that the offense will not be repeated, and a charge of one dollar will be required for turning the water on after it has been shut off for this cause.

A second violation of this rule will be considered sufficient cause for cutting the service off at the main, and refusing to re-connect same while the offender occupies the premises.

Failure to pay the cost of installing the fire service, or any subsequent repairs thereto, within thirty days after the receipt of the bill, will be sufficient cause for turning off the water from the supply.

In addition to our inspection, the local board of fire underwriters and other insurance associations maintain a rigid inspection, with

penalties for violation of their rules, one of which is that no water connections shall be made to the fire lines except for fire protection service.

Our inspections show that there is practically no stealing of water from fire lines in the city of Baltimore. Occasionally we find where some one through ignorance or thoughtlessness has made connection to a fire line, or uses water from fire hose outlets, but have never found a case so flagrant as to call for the extreme penalty.

The speaker has found as a general rule that the insurance people are fair in their demands on the water board, but sometimes make requests that are not altogether reasonable, for instance, where underwriters pumps are installed, they will ask for a suction from the city main equal in area to the suction outlet on the pump, regardless of the pressure on the main and the fact that pumps are designed to "take suction," under the most adverse conditions, and are provided with very liberal suction outlets. One of our rules covers this point clearly.

In a recent revision of our building law it is required that warehouses, factories, apartment houses, etc., shall be provided with fire standpipes with hose outlets on each floor. In time this will greatly increase the number of fire services in the city.

Mr. Walter Edward Miller: This matter of charge for services for private fire protection lines is one which is of special interest to the speaker at this time. He is so new a member here that he wishes to explain why he is interested. He is a member of the engineering staff of the railroad commission of Wisconsin. That commission is charged with the supervision of all public utilities in the state in the matter of rates and service. The commission now has before it the rate case of the Milwaukee water works, and in Milwaukee there are a great many private fire protection, or private sprinkler, systems; and the commission in that rate case probably will have to fix rates for those services on which some claim that there should be no charge. The commission will have to decide whether there should or should not be a charge, and if there is to be a charge, to say what that charge should be. The distribution system in Milwaukee is divided by closed gates or valves into a low and a high pressure system, the low pressure system being regulated by a large reservoir. The high pressure system is under direct pressure. As most of the manufacturing plants are in the low service district in which the pressure is not great at any

place, the speaker is inclined to think that most of these sprinkler systems must be served from elevated tanks on the buildings, which are probably supplied by private pumps drawing on the city mains. The speaker knows that there are a number of buildings with private elevated tanks on them. Whether or not they are for the purpose of maintaining pressure for fire protection systems he does not know.

The commission will be interested in finding out what the practice is or has been in other parts of the country; how many water plants are furnishing that service free, and for what reasons. The speaker can see reasons why the service should be furnished free, and he can see reasons why it should not be furnished free; there is a good deal that can be said on both sides. He is quite sure the commission has not made up its mind as to whether there should be, or should not be, a charge. There has not been a case yet in which that question has been involved, so that he does not know what the decision will be on the question as to whether there should or should not be a charge for that service. He is inclined to think, however, that at least one or two members of the commission are in favor of the making of some charge, though he has not discussed the matter with them.

It seems to the speaker that it is very nice to have faith in the honesty of your fellow men and to believe that they will not surreptitiously use city water from the fire protection systems; but in view of the fact that it is so frequently done it seems that the time has come when there must be some means provided for ascertaining whether the water that is being furnished the sprinkler systems under pressure is being used for any other purposes without a payment for it. It seems to him that the effect of the installation of a fire protection system in a private establishment upon the reduction of risk to the community must be considered. The fact is that when a fire occurs in a building thus protected, the sprinkler system, if it is in working order, will stand a good chance of quenching that fire before it gains headway. Many fires have been quenched by them before the fire department arrived. They have eliminated much work by the fire department, and have greatly reduced the quantity of water that has been used at such fires over what would have been used had not the sprinkler system been there. It seems fair to assume that the community derives a decided benefit from their existence, through their quick action and consequent reduction of fire loss, both in property and business and perhaps human

life. The speaker has not made up his own mind as to whether there should be or should not be a charge for such service and he would be very glad to hear the matter fully discussed by all those who have anything to say in reference to the subject.

Mr. E. E. Davis: We had a peculiar case the other day. The city of Manchester, south of Richmond, extended a main outside of the corporate limits into the yard of a large plant, under an agreement between the city of Manchester and the owner of the plant that if this fire hydrant was located there, the fire department was to be notified that that hydrant was available; so that matter came up before our assistant city attorney, and he called the speaker in and said: "Where are the fire hydrants located for the use of the fire department?" The speaker replied, "The list is published in the annual report." He said, "Have you any hydrants listed in that report that are located on private property?" The speaker answered "No, sir." He said, "This party seems to be of the opinion that if he has a fire and the fire department declines to come, that is a ground for a suit against the city." The speaker said, "He can sue the city of Manchester, and the city of Richmond owns that now by annexation." There is no rule requiring the fire department to go outside the city. A list of hydrants owned by the city is published every year, and the firemen get that.

Mr. W. Z. Smith: Mr. Clemmitt spoke of seals being broken. What do you do, do you penalize them when you have found the seals broken?

Mr. Robert L. Clemmitt: We instruct our inspectors, when they find seals broken to interview the owners or tenants and endeavor to ascertain the cause, and if it is a case of water stealing we turn off the water. In this event the insurance authorities are notified and they very quickly bring the offender to terms by cancelling his insurance until the water is turned on again.

Mr. W. Z. Smith: When you find they are taking water from the fire services or from the sprinkler systems, do you simply notify them, or do you assess any penalty against them, and make them pay for it?

Mr. Robert L. Clemmitt: It is a question of ascertaining just what was done and then applying the penalty as provided for by the regulations.

Mr. W. Z. Smith: Down our way we sometimes find it necessary to make them pay $50 for each seal that is found broken.

Mr. C. W. Wiles: The speaker has made some inquiry on this matter of compensation for fire protection, and has learned that in a number of cities and towns in New York State they make a charge based upon the insurance, which it strikes him is a very fair way. If a man saves 50 per cent, or 75 per cent, of his insurance by installing these fire protection services, it is right that he should pay the company or the city something for the fire protection. The charge referred to, based on the amount of insurance saving, is fixed at say 10 per cent of the premium paid for insurance. Whether or not a tax should be imposed for the benefit of the water department the speaker has not heard discussed, but he has understood that there is a charge based on their fixtures. The speaker does not know in how many cities they are using the method of basing the charges upon the insurance saving. It looks to him like a very fair and reasonable way of estimating the compensation to be received in return for the fire protection that a water company or water department is giving.

Mr. T. W. McNamee: We found the only solution, at least for us, of this proposition was the detector meter. We make a charge for that meter on the same principle as the minimum charge for any other meter, which in our case is $50 per annum for a 4-inch service, and $100 for a 6-inch; the consumer putting in the whole outfit.

Mr. C. B. Salmon: The speaker had occasion to investigate private interior fire protection about a year ago for a Virginia water works. He sent out a great many letters to both private and municipal plants in various states asking them what system of charging for sprinkler heads and different sized interior pipe openings they followed. In almost every case he found that where they made a charge they made a difference between a 4-inch and a 6-inch opening to the premises and also a sprinkler head charge added based on the number of sprinkler heads attached to the service. He also found in every case where cities were not charging for this service, they remarked that they thought that they ought to charge, or were going to try to get the council to allow them to charge. In every one of these cases there seems to have been the opinion that

some charge ought to be made, both with regard to the number of sprinkler heads and the size of the openings. He believes you should follow out the plan of making a minimum charge for 6-inch and 4-inch openings, with sprinkler head charge added.

He has always had the idea that a 6-inch opening ought not to be allowed on less than a 10-inch main. He has advised in some cases where they wish a 6-inch opening and the factory was large enough to justify it, where it was situated on two streets each having a 6-inch or larger main that they take one 4-inch opening off of each main and unite them inside the premises, with gate valves in the street, on each service at least 50 feet from the property line.

A few years ago there was a very disastrous fire in an Illinois plant which the speaker was rebuilding. They had a 6-inch opening into a starch factory taken from an 8-inch main. During the fire some of their heavy tanks on top of the building came down through, and broke off the distributing pipes on the different floors. They could not shut off the street valves, as they were too close to the building, and the whole district was in danger for a considerable time. The 6-inch opening was too large for the main and the water company could not get up any pressure, and the building burned to the ground.

Private water companiess as a rule do not like 6-inch openings even if people pay for them. When it comes to municipal plants, where a manufacturer has a great deal of influence, he can get almost anything he wants. The speaker thinks that there should be a different charge not only based on the number of sprinkler heads but on the different sizes of openings. He thinks Mr. Chester is right; it is a funny idea that the insurance company consents to a hazard to themselves when they ask for and permit such big openings, which they cannot possibly use, and which, in case of a break, entail a great hazard to the rest of their risks in the neighborhood.

The railroad commissions in Wisconsin are going into all of these fire supply matters in a thorough and systematic way, far more so than anything that has heretofore been done. The speaker has been under their supervision in one Wisconsin plant for four years, ever since they commenced their investigations, both as to valuations and as to rates. Some of you remember a paper the speaker read three years ago in Milwaukee upholding the commission in which he prophesied some things which he was awfully scared about at the time but which they have since practically carried out, not because of that paper, but because it was prophesied along the

lines that they were then considering doing. That commission has been very fair with all of our plants in Wisconsin.

The speaker wishes that any of you who can would give Mr. Miller of the engineering department all the facts you can. The railroad commission in Wisconsin is going to decide on interior private fire protection pretty soon. They are finding that municipalities are not paying for fire protection their just share of the public charge and they are raising the charge for fire service and lowering, in some cases, the domestic rates. The decisions of the railroad commission of Wisconsin on rates, on operation and on construction, where they have entered into it, are going to be just as effective and be quoted just as much as precedents in law in other like cases, as the decisions of the Supreme Courts of our different states. The speaker thinks courts are going to cite the decisions of the railroad commissioners of Wisconsin, because they are able men. They have able assistants and have made exhaustive investigations. For that reason every one of you should be very much interested in watching what Wisconsin does, because the speaker believes they are going to do it right.

Mr. J. P. Berry: In our town, Waterloo, Iowa, the city has recently purchased a plant. A number of sprinkler systems have been put in; and in order to get at a fair rate we talked to our merchants and manufacturers that were putting in these sprinkler systems, and asked them to help us to adjust a rate that would be fair. We took it up with them, and they all admitted that there should be some charge. One man in particular said, "I paid $3.60 a thousand insurance before I put in the sprinkler system; now I am paying 60 cents a thousand, and why shouldn't I pay the water department something?"

We have arranged there to charge $25 a year for a 6-inch connection, and one cent additional for each sprinkler head; and that seems to be satisfactory to them. We do not know whether those rates will be satisfactory to the water department or not. Those who have yard hydrants for private fire protection pay $5 for each hydrant, the hydrants to be sealed and all valves to be sealed. The board is very anxious to see this sprinkler system go in. We know several places where fires have occurred during the night, and the men coming on duty in the morning found the water running and the fire put out. We know that they have in a number of instances saved us pumping lots of water. For that reason our board seems

to want to do as much as they can, and we think they have done a little more than they ought to; but our people are willing to pay $25 a year for the 6-inch connections and the 1 cent for each sprinkler.

President Gwinn: I should think they would be.

Mr. Guy G. Crane: The speaker takes it for granted that you have all heard of our disastrous epidemics. Rockford boasted, for a number of years, of its pure, deep artesian well water. In January of this year we had a severe epidemic of intestinal grip, later followed by typhoid fever. Evidence obtained, by experts employed, showed three possible sources of contamination: One well was subject to contamination from surface water, the pumping pit was in the same condition, and, from the health commissioner's report, the majority of this epidemic originated in the near proximity to where there were sprinkler connections being supplied with other than city water, particularly water from the Rock River. This river is dammed within the city limits and has quite a few trunk line sewers emptying into it above the dam, where filth has been accumulating for a number of years.

Rockford is one of the chief cities of the world for the manufacture of furniture, and the furniture factories have a great many of these sprinkler connections.

The night of January 6, 1912, a large furniture factory located about two miles from our central pumping station burned, the building had a 6-inch sprinkler fire connection, which entered from an 8-inch water main. The burning building collapsed, breaking the fire connection, causing a full open drain on the 8-inch water main, making it useless for fire fighting purposes. This building was within 30 feet of another furniture factory and the only reason they saved the surrounding property was the fact that the same was located on the river bank, from which the steamers got water to fight the fire.

Investigation after the fire showed that the sprinkler valves were closed and that their tank was empty, in all probability due to an incompetent watchman. It is usual, in our city, for the fire department upon arrival at a fire to close or turn off sprinkler connections at the indicator posts to avoid an occurrence such as the speaker has just related.

The speaker has been in charge of the water department for about

two months. In order to eliminate the possible contamination of the city water he has discontinued the use of the contaminated well and pumping pit. From the results of a meeting of the manufacturers, insurance engineers and city officials we have required all sprinkler connections, where other than city water is used, to be equipped with special double check valves. Wherever this request has not been complied with we have shut off the connection. We contemplate requiring manufacturers to carry ten pounds excess pressure, in order to insure safe operation of these double check valves, and to prevent the waste of water in this way. The penalty for violating this privilege would be the installation of a detector meter.

The compensation for sprinkler systems is a thing that the speaker is not going to talk about as he is a new member in the association, and has been only two months in the water works business. But, we feel in Rockford that the taxes support the water department to a certain extent and our manufacturing interests support the city. It is a city of homes for working men. The speaker does not believe if he were asked the question, whether he would recommend a fixed cost for sprinkler systems, that he would know what answer to make; but, all he wants to do is just to tell you that your sprinkler connections should be kept distinct from any other source of water supply than the city supply, otherwise you may meet with very disastrous results.

President Gwinn: Do you now require all the sprinkler systems to be metered?

Mr. Guy G. Crane: No, but they must be furnished with special double check valves, as recommended by the Boston Manufacturers' Fire Protective Association. The placing of the detector meter is the penalty for the unlawful taking of water.

President Gwinn: The experience of Rockford is a very sad one. The citizens of Rockford might have learned from the experience of Lowell, Massachusetts, and several other cities where they have had similar experience with automatic sprinklers, which have not only cost the departments much money, but the loss of human lives.

Mr. George Houston: The speaker has been through this mill and has met all the obstacles that he has heard recited this

afternoon. A suggestion was made to him by a successful business man some years ago, with reference to the taking of stock inventory. He said, "I will tell you one thing, more business men fail from overestimating their assets than in any other way. When they inventory their stock they put it down as worth more than they know it is worth. They try to convince themselves that they are making a profit, when if on the contrary they would invoice the stock at its true value, and estimate the profits absolutely as they are, in the event that they have not been making enough money they would endeavor to put forth renewed efforts to increase profits instead of continuing to do business right along in the same way with the result of ultimate failure. If they would be frank with themselves they would meet with greater success, because the following year they would refrain from doing those things which would cause them to lose money."

Now the speaker wishes his remarks to be taken in that spirit. He cannot for the life of him understand how it is that any man who is connected with city water departments, and has his salary paid by the tax-payers of the city, can conscientiously state before this convention of water works people that "he cannot see why it is that people who install sprinkler systems for the protection of their plants should be subjected to a minimum charge." Such a man is simply inventorying his stock wrongly. The speaker cannot see how any intelligent superintendent can possibly take such a position. He knows of some cases where the insurance rates have been reduced from $1.40 to 25 cents per $100 a year. Surely in such a case a man should not object to being asked to pay a minimum rate for this service supplied through the sprinkler system which has given him such a reduction in insurance rates.

But if the reduction in rates was all we had to offer as a reason for making the charge, there might be some sense in the contention that the manufacturer ought to be relieved from the charge. But as was suggested by a previous speaker, there is this other dangerous feature coming in, as was experienced at Rockford, the possible and probable contamination of the city supply through the secondary supply of the sprinkler systems. Now these matters affect every citizen in cities where the risks are located. Our idea for making a minimum charge was not based on the insurance saving. We considered the matter from every conceivable standpoint, and finally arrived at the conclusion that the service was a very valuable one, and one for which the city should receive a fair com-

pensation by reason of the risks it has to carry in the way of danger of contamination, heretofore mentioned, as well as that of standpipes or risers of a sprinkler system breaking off in case of falling walls.

So we decided that an equitable method would be to make a minimum charge in the nature of an insurance premium on the risk the city had to carry on account of the dangers which are always the same for the same sized connections regardless of the size or value of the building in which they are placed, or where the building may be located. In other words, regardless of the size of the building, its value, or the amount that the owner saves in insurance it is a risk to the balance of the city by reason of the fact that the sprinkler pipe connection may break, and this risk would be the same to the balance of the city whether it was a million dollar plant with a 6-inch connection, or whether it was a plant of far less value. If the 6-inch connection broke it would endanger the fire protection of the balance of the city in that section, irrespective of the value of the plant; so we thought it equitable to charge according to the insurance risk. Then to determine what in our judgment would be a fair charge was the next question that confronted us, and as we could find nothing in the way of precedent to guide us, we had uphill work.

We finally concluded that if we made a minimum charge no greater than what it would cost the parties to maintain a secondary supply of their own, we would not be out of the way, so we inquired as to the cost of installing such a supply—that is an elevated tank and the necessary equipment—and found that those in our city cost anywhere from $3000 to $5000, so taking this as a base, and using the lesser amount and figuring interest, cost of operating and depreciation at 20 per cent, which is well within the limit, we found that it would make the cost to the building owner of maintaining this supply $600 per annum, and we do not believe that this is too much to charge for an 8-inch sprinkler connection, but as this seemed quite a large amount to pay for a service for which no charge had been made before, there was a great deal of opposition, so the rate was finally reduced and the ordinance we first passed placed a charge of $400 on an 8-inch line; $300 on a 6-inch line; $200 on a 4-inch line; $100 on a 3-inch line; $50 on 2-inch, and was passed by our council unanimously, with not a dissenting voice. Every line was to be metered, and all parties having sprinkler connections were notified and asked to place an order for a meter. Then our "fire-

works" began, as insurance men and delegations of manufacturers came before the council and contended that the sprinkler systems afforded a better protection to the city than it could possibly have with any kind of meters, because they were thoroughly inspected by inspectors who came at irregular times, and that in case they complained to insurance companies that water was being used from the sprinkler systems the risk would be canceled; and consequently no one using these sprinkler systems would attempt to take any water out of them surreptitiously. But as we had worked along on that theory for six years, and insurance men kept drilling into our council just that kind of an argument, and the quantity of water stolen daily increased as the years rolled by, they did not succeed in defeating the ordinance wholly this time. Two years ago we found that our water was being taken in large quantities in some manner that we could not account for, and finally we had this ordinance enacted. The thing they objected to most strenuously was the minimum rate, and finally there was a repealing ordinance brought up to repeal that minimum feature. As a matter of compromise we assented to a reduction, and the rates are now fixed at $100 on 8-inch; $75 on 6-inch; $50 on 4-inch; $25 on 3-inch; and $10 on 2-inch connections. These are now our rates.

With reference to the surreptitious taking of water, this is the matter that the speaker had in hand at the Rochester convention, but inasmuch as the paper read there would not permit of that, logically, in its discussion, it was simply left out.

A certain company that was one of the most vigorous kickers against the installation of meters on sprinkler lines, and strongest in protesting that it was not taking any supplies from the sprinkler system, was forced to put on a detector meter. The meter was on the ground for two weeks before it was installed and all of this time they were making heroic efforts to get rid of the method that they had been resorting to to get water during a period of four or five years; but nevertheless we put the meter on, and in the first forty-eight hours after its installation it showed that they had used upwards of 50,000 cubic feet of water through that detector meter even after they had had two weeks time in which to prepare to avoid such use. Now, it is claimed that it is utterly impossible to take water through a fire line sprinkler system without its being discovered. The insurance companies will tell the city councils that it is impossible; but when the speaker hears such arguments advanced they actually make him sick, because he has been through the mill

and knows how untrue they are; and they will keep it up just as long as you will let them and as long as you will believe them. The night before that ordinance was enacted the insurance men came before our council and said, "As sure as you place those meters on we will raise your insurance rates." But they didn't do it; in fact they have reduced the rates five cents on $100 on one risk,

Now, somebody has suggested the putting of a meter on a bypass and placing a seal on it. We tried that with this same company that stole 50,000 cubic feet of water in forty-eight hours. Our man inspected it regularly. We had two chains put on over the spokes of the wheel on the stem of the valve and then passed around under the valve, with two padlocks on them, thereby making an apparently safe seal, but we discovered that they were taking water in the amount that has been stated, and we discovered how it was done. They had removed the nut from the top of the valve stem which held the wheel on, and then with a lever pried the wheel up, and with a wrench turned the valve on, then replaced the wheel and replaced the nut that held it on, all the while leaving the seal intact. All this was brought out in court.

Another large institution had four connections, one 8-inch and three 6-inch, and resisted our demand that they put on detector meters for a long time. Finally when they felt that we were really in earnest and had already cut off two other institutions, they told us, "All right, go ahead." After the detector had been on a month although they had denied right along that they had been using any water, we found that they had used 20,000 cubic feet, but they would not admit they had ever used an ounce before. They then discovered that they could not get along without the city water, because the health board was complaining about their men having to drink other water, and they said they would take the city water so as to have drinking water. They pay us now $40 or $50 a quarter. The question is, what were they doing for drinking water up to this time?

The speaker might add that the institution wherein we discovered the large use of water through the sprinkler system was a paper mill, and that they had placed some twenty-seven taps on the sprinkler system, and had been taking water in that way for four years or more. They used it in the beaters, in their chests, and in their supply tank, and during the entire season from about the middle of June up to the first of September, by a proclamation issued by the mayor, the people of the city had been instructed to restrict

their sprinkling to one hour a day. The west side were to sprinkle one hour on one afternoon, and the east side one hour the next afternoon, alternating every other week; and half the time the people could not get any water at all for sprinkling, and on the heights they had hardly any pressure for domestic use. So all that season a great majority of the people of the city were very much restricted in their use of water, besides there was no street sprinkling to speak of, and it was all because of the waste that was going on in these large institutions through sprinkler systems. After the installation of the meters, and after putting in 800 more meters, everybody in the city was getting all the water they wanted at all times of the day, and no diminution of pressure, and our revenues increased over $10,000, and our consumption decreased about 7,000,000 to 10,000,000 gallons a month. Suit was brought against this company, a civil suit, and we had the superintendent and the general manager arrested and prosecuted criminally. Neither of these criminal cases has been brought to a conclusion as yet; in fact the case before the recorder's court in the first instance has not been finished for the reason that the defendant had a stroke of apoplexy and has never recovered from it. The second man, the superintendent, is in a neighboring city working in a paper mill there; consequently the criminal cases are standing about as they were, but in the civil case we asked for an accounting. We rendered them a bill based on the consumption of water the first forty-eight hours after the installation of the meter, brought the case to trial last December, and in January got a verdict for fifteen thousand eight hundred and some odd dollars. They took an appeal to the Supreme Court and the case is there now; but there is a move on foot on the part of the defendants to make the best settlement they can. We anticipate that they will pay the full judgment. If the case ever comes to trial again we have a lot of additional evidence and we think we will make even a better case and get a judgment for a larger amount.

Mr. W. J. Wills: Here is the predicament we are in. We figured out a fair scheme, but the insurance companies know which cities do charge and which do not, and they have furnished to the Memphis Manufacturers' Association the names of all the cities that do not charge at all.

Mr. George Houston: The speaker wrote one hundred and thirty-eight letters to different cities throughout the United States,

making inquiry on this subject, and out of all the replies that he received there were only two that indicated that the writers of them were not in favor of making a charge. All except two voiced the sentiment that has been expressed here this afternoon, that many of those who did not make a charge thought they ought to. That is the trend of the sentiment, and in conclusion let the speaker say with all the earnestness that he possesses—make them put on meters and make them pay a decent minimum charge.

Mr. S. J. Rosamond: Mr. Wills seems to be after information as to what cities do make a charge. The speaker would state that five years ago this question came up in his city, and an effort was made to force his corporation to render the service without charge; but he succeeded in convincing the council that such a service if given free would be a discrimination, and he had a charge established. Our charge was $50 per annum for 6-inch and 4-inch connections, $25 for 2-inch. Since then that corporation has been transferred to the city, and the manufacturers and insurance men have again taken the matter up and tried to get the charge removed. Mr. Bruce who succeeded the speaker was well posted on the proposition, as it is one of the things that he knew had been thrashed out before, and he told the speaker last fall that a rate had now been established there which is practically the same as the other. The speaker did a great deal of corresponding, as the gentleman from Kalamazoo says he did, and went into the matter very thoroughly. He never has been able to see where there is any good reason for furnishing such a service without charge.

Mr. George Houston: The speaker forgot to state that we require the parties to pay for the meter and its installation, and allow them to tap on the fire line between the meter and the check-valve, and take from that a domestic connection for supplying water throughout the mill, so that they get that benefit; and we then allow the minimum charge to apply on the water rates to its extent, only paying more when the amount of water used at the regular rate exceeds the regular minimum charge. In other words, they get the benefit if they want to use that much water.

Mr. Dow R. Gwinn: May the speaker recommend to Mr. Wills that he have the courage of his conviction and run the water department himself, not let the manufacturers run it for him.

The experience of the city of Rockford shows that the manufacturers were jeopardizing the public health by their automatic sprinklers. There is no reason why either a private water works or a municipal water works should furnish this fire protection free. Let the manufacturers furnish it themselves; they can do it. The only reason that they take it from the water works is because they think they can get it cheaper than they can the other way.

Some years ago the question came up as to sprinklers in a large manufacturing plant in our city. The principal representative of the Western Factory Mutuals came to our city to look over the situation. The speaker asked him what he thought the concern ought to pay for sprinkler service if we furnished it. The gentleman understands the business thoroughly and has been with the fire insurance interests a great many years. He said that they ought to pay a sum which would be equal to the cost to the factory men if they provided and operated their own plant for that purpose, including interest, depreciation, operation, taxes and extra labor. In the case under discussion, he estimated that the amount would be approximately $600 per annum. Please bear in mind that this opinion was given by an expert insurance man.

No such risks should be taken as were taken in the city of Auburn, New York, the City of Rockford, Illinois, and the city of Lowell, Massachusetts. If forty lives were lost in battle, the news would be telegraphed all over the globe. The lives of citizens are of far greater importance than the matter of saving $500 or $1000 a year by some manufacturing concern. We think that furnishing such service free is a mistake; that the insurance people themselves should not ask for that sort of service, because whenever a large fire service pipe or main is broken, the service of the balance of the city is placed in jeopardy. The speaker believes that some day insurance interests will not ask water works companies or water works departments to furnish that service at all, for the reason that it may tend to a greater conflagration risk as a result of trying to save money for manufacturers.

We believe that we have practically solved the problem in Terre Haute by requiring that no tap shall be made larger than four inches, and all service pipes one inch and larger shall be metered. On 4-inch lines, we require a detector type of meter. We also require a minimum rate of $20 per month for a 4-inch meter and the consumer may take $20 worth of water for the minimum rate, so that if he uses $20 worth of water or more, the service does not cost him a cent.

In connection with that will say we have a 2-inch service. This shows that the insurance interests are satisfied with a 2-inch connection.

The question is whether you gentlemen are going to run the water works business and take care of your citizens and your customers, or whether you are going to turn it over to the manufacturers or to the insurance companies? The speaker for one, says to the manufacturers, "Get your fire protection somewhere else, provide it yourself; but if we must provide it, you can not have any connection with any other source of supply, and you must pay us a liberal minimum rate and take your supply through a meter."

To what depth did frost penetrate during the extreme cold weather of the past winter?

ALTOONA, PA. $3\frac{1}{2}$ to 4 feet.
BRADFORD, PA. About 5 feet.
BUFFALO, N. Y. 6 feet.
CHAMPAIGN, ILL. 3 feet.
DUBUQUE, IA. Averaged 6 feet with cases on exposed streets of 7 feet.
EAST LAS VEGAS, N. M. 3 feet.
EL PASO, TEXAS. No frost to contend with.
ELYRIA, O. 42 inches.
HOQUIAM, WASH. 2 to 3 inches.
LAKE FOREST, ILL. 5 feet.
MOBILE, ALA. No frost.
MONESSEN, PA. $3\frac{1}{2}$ feet.
NEW ORLEANS, LA. About 1 inch.
NORTH ATTLEBORO, MASS. $5\frac{1}{2}$ feet.
QUINCY, Ill. 36 inches,
RAHWAY, N. J. 32 inches.
RICHMOND, IND. 4 to 5 feet.
SAULT STE. MARIE, ONT. 6 feet.
SPOKANE, WASH. 2 feet.
STRATFORD, ONT. 3 feet.
STREATOR, ILL. 4 feet.
SUFFERN, N. Y. Over 4 feet.
TOLEDO, O. 5 feet.
WALKERVILLE, ONT. 36 inches to 54 inches.

How much below ordinary depth did frost penetrate?

Altoona, Pa. 12 inches.
Bradford, Pa. About 2 feet.
Buffalo, N. Y. 2 feet.
Champaign, Ill. $1\frac{1}{2}$ feet.
Dubuque, Ia. About 2 feet.
East Las Vegas, Tex. About 1 foot.
Elyria, O. 8 inches.
Lake Forest, Ill. 18 inches.
Monessen, Pa. 1 foot.
North Attleboro, Mass. $2\frac{1}{2}$ feet.
Quincy, Ill. 18 inches.
Rahway, N. J. 18 inches.
Richmond, Ind. About 1 foot.
Sault Ste. Marie, Ont. 1 foot.
Stratford, Ont. Not below average.
Streator, Ill. 1 foot.
Suffern, N. Y. 2 feet.
Toledo, O. About 2 feet.
Walkerville, Ont. 18 to 36 inches.

Were any water mains in the "Gridiron System" of the distribution, having a circulation, i. e., mains other than dead ends, frozen?

Altoona, Pa. No.
Bradford, Pa. No.
Buffalo, N. Y. We had one or two 6-inch mains frozen this last winter, that were not dead ends, but the street had been graded down so that the pipe was only about 2 feet in depth.
Champaign, Ill. No.
Dubuque, Ia. No.
East Las Vegas, N. M. No.
Elyria, O. No.
Hoquiam, Wash. We have never had a large main frozen.
Lake Forest, Ill. No.
Mobile, Ala. No.
Monessen, Pa. No.
North Attleboro, Mass. No.
Quincy, Ill. No.

Rahway, N. J. No.
Richmond, Ind. No.
Sault Ste. Marie, Ont. No.
Spokane, Wash. No.
Stratford, Ont. No.
Streator, Ill. No.
Suffern, N. Y. None.
Toledo, O. No.
Walkerville, Ont. No.

What, if any, means are used to prevent the freezing of mains, hydrants and services, during the extreme cold weather?

Altoona, Pa. No means used by department. Citizens allow spigots to run.

Bradford, Pa. Blow them off frequently.

Buffalo, N. Y. Where mains are exposed crossing bridges, we box the main and pack with sawdust. Place an iron cover over every hydrant in winter and fill it with straw. Have hydrants in business section examined every day and in outlying districts about once a week.

Champaign, Ill. None, other than see they are properly covered.

Dubuque, Ia. Daily draw until clear, and put good supply of salt on top of valve in hydrant.

East Las Vegas, N. M. All mains covered 3 feet. No other means used.

Elyria, O. None.

Hoquiam, Wash. Usual means employed is to allow water to run, although the rules of company forbid such use. Several years ago we had our entire system absolutely drained during cold weather by reason of excessive waste, and were obliged to shut off several hundred consumers who were thus wasting water before we could reinstate our water supply.

Lake Forest, Ill. Hydrants which were most exposed were banked with manure.

Monessen, Pa. None.

North Attleboro, Mass. Allowing water to run.

Quincy, Ill. Inspection of fire hydrants in the fall, to see if barrel drains properly. If hydrants are used in cold weather, they are inspected to see whether drainage is all right.

Rahway, N. J. Only frequent inspection of those fire hydrants that are located in very wet and non-draining sections, and if water is found in hydrant barrel, we pump it out.

Richmond, Ind. Where ground water enters the drip hole of hydrants and same cannot be drained into the sewer, we put a box around the hydrant and filled it with manure, which has proven satisfactory for a number of years. In case of dead ends during the severe weather, we took tests two or three times a day of the temperature of the water and if it reached within one or two degrees of the freezing point, we either flushed the main or allowed a small stream to run. This same attention was given to hydrant branches that were not laid to a depth of 5 feet. We had a number of services freeze, but in most cases this was due to the fact that they were not laid to the required depth of 4 or $4\frac{1}{2}$ feet. We did not pay much attention to the services, having our hands full looking after the mains and hydrants.

Sault Ste. Marie, Ont. None with respect to mains and services. Hydrants are pumped out carefully by small hand pumps as we do not depend on the automatic drainage of same.

Spokane, Wash. Consumers on flat rate let faucets run. Fire hydrants are all drained and inspected. One instance on nonstandard depth of main was remedied by a $\frac{3}{4}$-inch tap especially made for the emergency.

Stratford, Ont. Some hydrants whose drainage is known to be poor were banked around with stable refuse as dry as possible, so as to give them as good covering as possible before the permanent snowfall came.

Streator, Ill. Constant inspection.

Suffern, N. Y. None.

Toledo, O. None, but test hydrants each day to see if frozen.

Walkerville, Ont. Mains, none. Hydrants, keeping dry.

Mr. W. R. Young: That matter was brought to the speaker's attention very forcibly last week when he learned that the fire chief at Minneapolis was going to read a paper before the National Association of Fire Chiefs on the subject of the proper means of taking care of fire hydrants to insure against their being frozen during the cold winter months. We have not had much experience in Minneapolis with the freezing of hydrants.

Although the frost has gone down as deep as 9 feet we have had no water mains frozen. Branches in a few cases have been frozen,

but we have made a systematic examination of the fire hydrants of the city no further apart than every two days. Ordinarily in the business district every fire hydrant is examined every twenty-four hours when the temperature is down from 15° to 30° below zero. We were extremely fortunate in one large fire, in which oil tanks on the east side of the river were burned and when there was a general alarm sent out. As many as thirty hydrants had to be put into action at that time, and not one of them was found out of condition on account of frost. Our plan was to flush them and wash the ice out as fast as it would form. The speaker does not think that we had during the winter all told ten fire hydrants that it was necessary to take up in order to thaw them out. Another precaution taken was to make a very strong solution of salt water and kerosene and put this in the barrel of the hydrant which prevents it from freezing under ordinary circumstances.

Mr. John M. Diven: What effect does the strong salt solution have upon rubber valves or leather washers?

Mr. W. R. Young: It does not seem to have any effect upon them, because it is above the seat. Our fire chief's paper on the subject seemed to me rather interesting both from the fire standpoint as well as water works department viewpoint.

Mr. A. Maclean: We have had considerable experience operating in a cold country as we do, and the compression hydrants give us a great deal of trouble. We find that on top of the valve there is a small seepage of water which freezes. After having carefully studied the situation, we drew up a set of specifications calling for a slide gate hydrant with a nipple connected to the end of the drip which would connect to the sewer so that when the hydrant was closed it was absolutely drained into the sewer. We have not had one bit of trouble with those hydrants during the winter. We inspect them every day throughout the winter months, examine and test them.

Mr. J. M. Diven: During the extreme cold weather of the winter of 1903–1904, some fire hydrants in a very exposed situation at Elmira, New York, froze. The hydrants protected a large factory, and it was important that they should be kept ready for use. They were thawed by electricity several times, but, as the frost

had penetrated below the branch pipes, they froze again in a very short time. As there was no sewer, it was not practicable to let the water run. The street was excavated to the branch pipes, from the main to the hydrant, by the usual method of building fires and excavating the thawed out layers of earth; the excavation extending to the bottom of the branches. The space around the branches was then packed with fresh stable manure, and the trenches refilled.

During the remainder of the winter there was no further trouble with these hydrants. When water was drawn from these hydrants, in testing them, it felt warm to the hand, showing that it was much warmer than the water in the mains.

This was adopted as a temporary expedient, but the present superintendent at Elmira says that these hydrants gave no trouble during the excessively cold weather of last winter, which was a severe test.

The speaker cannot say whether the manure corroded the iron, but thinks it would be apt to, and would recommend a layer of dry earth between the pipe and the manure; or, what would probably be better, putting the manure below the pipe, so that it would not come in contact with it. It would probably be as easy to lower the pipe as to do this, and it is only suggested for some place where it would not be expedient to lower the pipe; for instance, where a hydrant branch leaves a shallowly laid main to take care of the part of the branch near the main that could not be lowered and might freeze as the water in it would have no circulation.

Mr. William Luscombe: What preparation, if any, was made to put the hydrants in first-class condition for the winter that was spoken of by the gentleman from Minneapolis? Referring to the use of salt water, the speaker has used that with poor success. He found that it corroded the iron so that it tended to choke up the waste and prevent the hydrant from properly draining. He uses crude oil with better success.

President Gwinn: How much do you put in?

Mr. William Luscombe: Four to six inches of crude oil in each hydrant.

Mr. F. J. Connor: The speaker's experience with the salt proposition was that we did not have any occasion to flush those hy-

drants afterwards but it seemed to corrode the caps. We found that to be one fault. One year we took a little of this salt brine and some kerosene and just a little wood alcohol, probably put in half a pint of wood alcohol in some of the hydrants that were bothering us because they seemed to show a tendency to freeze. This last year we had no frozen hydrants at all. Some insurance inspectors came in and inspected thirty or forty hydrants in the business and residence district and found that everything was all right. We inspect all the hydrants in the city at least two times a week. We have less trouble with our fire hydrants freezing than with our other services. We have also used fresh horse manure about the hydrants and found it to work well.

Mr. A. Maclean: Do you not find that the manure injures your pipe? The reason that that question is asked is that we laid a few services during the winter, and as the temperature went down to 50, 60, or 70 below zero we covered them with about a foot of manure. They were in about two years and we had to take them all out, they had all rotted away, they were galvanized iron pipe.

Mr. F. H. Connor: If we can get hold of some dry sand, or some dirt that is not too wet we fill it around the pipes and put the manure in over that. We do not know whether it was the manure or some other action that caused those galvanized iron services to give out.

Mr. E. H. Breidenbach: We pump our hydrants out in the fall, and every hydrant that is opened must be reported to us immediately. We make it the duty of one man to keep the hydrants pumped out during the cold season, and we have found that very easy to do.

Mr. T. C. Phillips: Our experience in Chicago may be of interest to you. We have about 25,000 hydrants, a large percentage of which have hydrant basins. These basins are filled with manure in the fall and cleaned out in the spring. This process of preventing freezing is expensive. During the past three years we tried filling the hydrant basins with dirt letting it remain permanently. Where this was done the hydrant drain was directly connected with the sewer and the basin abandoned. During the winter of 1911–1912 the frost penetrated to a depth of about 5 feet. Less trouble

was experienced from freezing with dirt filled hydrant basins than with manure filled hydrant basins. The present policy of the water department is to install hydrants without basins, except in streets where the subsidewalk space is occupied.

What action was taken when mains were frozen?

Altoona, Pa. Used electricity, but were compelled to dig the main up in one case, it being a 6-inch main. The 4-inch main which was thawed out by current was found burst. The 6-inch main did not burst.

Berlin, Canada, Electricity.

Bradford, Pa. Had small portion of dead end of a 6-inch main freeze last winter. Allowed it to remain until it thawed itself out.

Buffalo, N. Y. We dig up the frozen mains and thaw them out, using a small portable steam boiler. We have tried electricity, but our experience was that the pipe burst in a number of places and had to be dug up and replaced anyway, and that we had thawed out only a part of the ice, adjoining the pipe.

Dubuque, Ia. Worked steam by $\frac{3}{4}$ hose through hydrant to main if not too far. Freezing usually at valve 4 to 6 feet from hydrant.

East Las Vegas, N. M. Taken up and thawed out.

Monessen, Pa. Dead ends were thawed by coal fires built on top of trench over the main.

North Attleboro, Mass. Thawing out by electricity. The electric light and water departments of the town of North Attleboro are under municipal control and under the same management, therefore access to the electric current was very convenient. The equipment consist of two 20 k. w. transformers, 2200 volt primary and 220 volt secondary current, the 220 current used for the thawing. An ammeter was connected in the circuit so as to determine the amount of current to be used on the various kinds and sizes of pipes. The amount of current determined for thawing was found by experimenting in about one-half day's time. Regulating the current was by the means of water in ordinary oil barrels; by bringing the terminals nearer to each other in the barrel this would increase the current and visa versa decrease the current.

Current required to thaw water mains of cast iron pipe: 4-inch pipe 1400 to 1900 amperes at 220 volts; 6-inch pipe 1900 to 2300 amperes at 220 volts.

The time required was from fifteen to twenty-five minutes.

The transformers were overloaded from 100 per cent to 300 per cent during this operation. Transformers used were the ordinary lighting transformers of the General Electric make.

QUINCY, ILL. By building wood fire around it.

RAHWAY, N. J. Had none.

SAULT STE. MARIE, ONT. One 4-inch main thawed by electric current as soon as same was found to be frozen.

SPOKANE, WASH. Used steam boiler. Also electric current.

SUFFERN, N. Y. One section (250 feet) thawed out by steam, inserting 1-inch pipe in 4-inch main from dead end. Mains entirely opened in 3 or 4 hours. Another section about same distance, dead end, thawed out in 30 minutes by electricity.

TOLEDO, O. Had only one main frozen last winter and that was a dead end. In order to thaw this out we made two $\frac{5}{8}$-inch taps on the main after digging up the ground at the point where we supposed the main to be frozen, and then had a fire steamer pump steam into the main. The hydrants at either side of this main we left open, and in a few moments the water in the main began to flow.

What action was taken when hydrants or hydrant laterals were frozen?

ALTOONA, PA. We had no frozen laterals and only one hydrant. We used salt and also wrapped sacking around the outside, pouring hot water on the sacking.

BERLIN, CANADA. Thawed with hot water.

BRADFORD, PA. Used electricity very successfully.

BUFFALO, N. Y. Same as frozen mains.

DUBUQUE, IA. Used steam to thaw out.

LAKE FOREST, ILL. Some hydrants were found to be stuck, but by means of a handful of salt inserted in the nozzle, they were loosened up.

NORTH ATTLEBORO, MASS. Same as for mains.

QUINCY, ILL. Salt poured into barrel and flushed out thoroughly after ice was melted.

RICHMOND, IND. Where hydrants were frozen, due to leaky valves or ground water, same were generally thawed out by means of hot water or a fire around the hydrant. Where ground water entered the hydrant through the drip hole, we used denatured alco-

hol, pouring same into the hydrant and found it remedied the trouble completely, so much so that all hydrants that give us trouble next year will be treated in this manner.

Sault Ste. Marie, Ont. Slightly frozen, throw handful salt and hot water into barrel. Where frozen hard, or lateral frozen, electric current is applied.

Spokane, Wash. Usually built fire around the hydrant.

Stratford, Ont. Dig away all the loose top stuff and put in stable manure as hot as we can get it. Salt will do the work, but it is ultimately very corrosive on metal and joints.

Toledo, O. Forcing steam into the hydrant barrel.

Walkerville, Ont. Hot water or steam.

What action was taken when service pipes were frozen?

Altoona, Pa. Citizens used electricity.

Berlin, Canada. Thawed by electricity.

Bradford, Pa. Electricity.

Buffalo, N. Y. All services are put in by the property owners and maintained by them. Plumbers in thawing them out generally use small tubing to push through the service and pour hot water into the frozen part.

Champaign, Ill. Steam.

Dubuque, Ia. Dig up and thaw out with wood fire on trench.

East Las Vegas, N. M. Consumers care for service pipes.

Elyria, O. Dug them up and repaired them.

Lake Forest, Ill. Thawed by electricity at expense of consumer.

Current and time required to thaw water pipes by electricity

SIZE PIPE (IRON)	LENGTH	VOLTS	AMPERES	TIME REQUIRED TO THAW
inches	*feet*			
¾	40	50	300	8 minutes
¾	100	55	135	10
¾	250	50	400	20
1	250	50	500	20
1	700	55	175	5 hours
4	1300	55	260	3
10	800	62	400	2

To thaw out lead pipe, increase the amperage 50 per cent.

Mobile, Ala. When service pipes were frozen and not promptly repaired by consumer to prevent waste of water, water is cut off until repairs are made.

Monessen, Pa. Electricity.

North Attleboro, Mass. Same method used in thawing water mains. The current used to thaw a $\frac{3}{4}$-inch lead service would require 600 to 900 amperes, while an ordinary galvanized iron pipe of the same size ($\frac{3}{4}$-inch) would require 400 to 500 amperes. The time required in thawing would be from four to eight minutes, in each case. Our lighting wires were not always available where the pipes were frozen, consequently our cable had to be run in some instances 1200 feet to the service pipe in the cellar, while the other end would be connected to the nearest hydrant, which would be available within 300 feet as the hydrants are located on an average of every 500 feet. The water supply system covered more territory than our lighting wires. A great deal of judgment had to be used as to the quantity of current on account of the age of the galvanized pipe; when the pipe was very old the current applied would not be as strong as that of new pipe owing to the liability of burning the service pipe off. In carrying the wires to the house or service to be thawed, they were run on top of the ground. The men required were electric department, two linemen, these men would attend to connecting transformers to the 2200-volt lines and making the necessary taps from the wire reels to the water barrels. The 4 water department men would run cable to the service, remove meter and place in service a nipple to take the place of the meter so consumer could secure water. The two linemen would connect to hydrant by the means of a ring made to fit hose nozzle. On an average 15 services were thawed out in a day and in some cases as high as 22 services. Most of the time was spent in getting our equipment in readiness and connected. In one connection or location we have thawed out as high as 12 services; the average would be around 3 services without relocating our equipment. In seventeen days we thawed out 150 service pipes, two 6-inch cast iron water mains, seven hydrants and one 4-inch cast iron water main.

Quincy, Ill. The only service pipes frozen were of galvanized iron and in nearly every case the pipe burst and it was necessary to dig and replace the broken pipe.

Rahway, N. J. Do not repair service pipes. Work being done by plumbers at owner's expense.

Richmond, Ind. Where freeze could be shown to be between

the main and the curb, the company thawed the service electrically, without expense to the consumer. Otherwise a small charge was made to the consumer.

Sault Ste. Marie. Thaw as soon as possible with electricity.

Spokane, Wash. Steam and electric current.

Stratford, Ont. Open them up, break connection and turn in steam jet from small portable boiler.

Suffern, N. Y. Taken care of by owners.

Toledo, O. Taken care of by owners.

Did frozen mains burst from expansion of water on freezing?

Altoona, Pa. One 4-inch main.

Buffalo, N. Y. Yes.

Dubuque, Ia. Had only one break from frost—pipe line 150 feet.

East Las Vegas, N. M. Sometimes, but not usually.

Hoquiam, Wash. No.

North Attleboro, Mass. No.

Quincy, Ill. No.

Rahway, N. J. No.

Sault Ste. Marie, Ont. No.

Spokane, Wash. No.

Stratford, Ont. Yes.

Suffern, N. Y. Yes.

Toledo, O. No.

Walkerville, Ont. No.

Did frozen services burst from expansion of water in freezing?

Altoona, Pa. About a dozen. These only occurred where allowed to stand for ten days or two weeks. In the 4-inch main which was frozen for a distance of probably 50 feet, about 14 feet was found to be burst.

Berlin, Canada. No.

Bradford, Pa. A few.

Buffalo, N. Y. Yes. Worse in iron than in lead pipe.

Champaign, Ill. A few.

Dubuque, Ia. Yes, a good many.

East Las Vegas, N. M. Usually, but not always.
Hoquiam, Wash. Many.
Lake Charles, La. Quite a few.
Lake Forest, Ill. Yes. These were found to be affected in the goose neck between the main and the iron pipe.
Mobile, Ala. Yes.
Monessen, Pa. Yes.
North Attleboro, Mass. No.
Quincy, Ill. Yes.
Rahway, N. J. Yes.
Richmond, Ind. No.
Sault Ste. Marie, Ont. No.
Spokane, Wash. No.
Stratford, Ont. Yes.
Suffern, N. Y. Yes.
Toledo, O. No.
Walkerville, Ont. Many.

What effect did material of service have on the action of frost?

Altoona, Pa. Use only galvanized pipe, and therefore have no experience with other material. A service pipe say 25 feet long was burst for a distance of 6 to 8 feet.
Buffalo, N. Y. Worse in iron than lead pipes.
Dubuque, Ia. Lead held best.
East Las Vegas, N. M. All services wrought iron.
Elyria, O. See no difference between lead and iron.
Hoquiam, Wash. All service pipes under 2 inches are galvanized pipes. We have used some 2-inch wood pipe. Think the wood pipe never has frozen. Galvanized pipe shows greatest injury from freezing.
Quincy, Ill. Had no services broken by freezing except galvanized iron pipe.
Stratford, Ont. Ductile metal expands, so that the effect usually does not go beyond an alteration in the shape of the pipe. Cast iron fractures, lead and good wrought iron do not.

What was the effect of cold weather on water consumption, or how much or what per cent above normal consumption was wasted to prevent service or house pipes from freezing?

Altoona, Pa. Consumption practically doubled.

Berlin, Ont. Our pumpage increased about 25 per cent. Considerable of this was lost through broken hydrant laterals. The water got away in a storm sewer, and was not discovered for some time.

Bradford, Pa. From 25 per cent to 35 per cent.

Buffalo, N. Y. Marked increase in consumption in cold weather. Average pumpage is 135,000,000 gallons per day. In very cold weather we have pumped over 200,000,000 gallons per day.

Champaign, Ill. Not over 10 per cent.

Dubuque, Ia. About 5,000,000 per month increase December, January and February on an average of 52,000,000 per month.

East Las Vegas, N. M. No appreciable effect is determined by pressure gauge.

Elyria, O. Our little *meters* did the work. Superintendent listened to the kicks later on.

Hoquiam, Wash. About 50 per cent, in some cases as high as 100 per cent increase in consumption.

Lake Forest, Ill. Our pumpage during the month of January was increased to such an extent as to make the pumpage for that month the highest of any month in our fiscal year from the first of May, 1911, to May 1, 1912, with the exception of the month of July, the pumpage being 20 per cent higher than the highest pumpage in the same month in any of the four previous years.

Mobile, Ala. Much above normal. Percentage cannot be stated.

Monessen, Pa. Twenty-five per cent.

New Orleans, La. Slight.

North Attleboro, Mass. Twenty-four per cent.

Quincy, Ill. About 60 per cent of our services are metered. Am unable to give any data on the increase of metered consumption due to cold weather. Am inclined to believe that the increase was nearly as much as in the flat rate consumption. The average daily consumption for January and February was about 5 per cent in excess of that for November and December. From the first to the twentieth of January, during which period the weather was almost continually below freezing, the average daily consumption was about 20 per cent over the November and December consumption.

Rahway, N. J. In January, 1911, we pumped an average of 1,788,879 gallons, in 1912, 2,311,246 gallons; in February, 1911, 1,681,664 gallons; 1912, 2,363,962 gallons.

Richmond, Ind. Approximately 15 per cent.

SPOKANE, WASH. Twenty per cent.

STRATFORD, ONT. A marked lowering of temperature, 20–25° below zero will increase total pumpage about 33⅓ per cent, about half the house services being metered.

STREATOR, ILL. Twenty-five per cent.

SUFFERN, N. Y. Twenty to 25 per cent.

TOLEDO, O. Eight per cent over the average for the year.

Was water "wasted" to prevent freezing of hydrants, hydrant connections, public fountains or fountain connections?

ALTOONA, PA. No.

BERLIN, CANADA. Several hydrants, after the mains had been thawed, were flushed every day to prevent freezing.

BRADFORD, PA. No.

BUFFALO, N. Y. No.

CHAMPAIGN, ILL. Yes, to some small extent.

EAST LAS VEGAS, N. M. No.

ELYRIA, O. No.

HOQUIAM, WASH. No.

LAKE FOREST, ILL. No.

MOBILE, ALA. No.

MONESSEN, PA. No.

NEW ORLEANS, LA. No hydrants. Sometimes fountains.

NORTH ATTLEBORO, MASS. Yes.

QUINCY, ILL. No.

RAHWAY, N. J. No.

RICHMOND, IND. Comparatively small amount.

SAULT STE. MARIE. No.

SPOKANE, WASH. Public drinking fountains were left running all winter.

STRATFORD, ONT. No.

STREATOR, ILL. No.

SUFFERN, N. Y. No.

TOLEDO, O. No.

WALKERVILLE, ONT. No.

What means were adopted to check "Cold weather waste" of water.

ALTOONA, PA. Where we detected those allowing water to waste, they were arrested and fined.

BERLIN, CANADA. We had 2872 consumers. Of these 2229 were metered.

BRADFORD, PA. None.

BUFFALO, N. Y. We object to allowing water to run to keep from freezing, but are not very insistent. If we can get meter placed without too much opposition, we do, only 25 per cent of our consumption is metered.

CHAMPAIGN, ILL. Flat rates were inspected. Make no objection to meter consumers wasting.

DUBUQUE, IA. None, as 97 per cent are metered.

EAST LAS VEGAS, N. M. None.

HOQUIAM, WASH. It has been our custom to send out notices to our customers requesting them to prevent their pipes from freezing before cold weather arrived. This has been of some benefit, though, as a rule, consumers pay no attention to the notice.

LAKE FOREST, ILL. All service metered.

MOBILE, ALA. Arrest and fine of offenders. Also increase in metering of services.

MONESSEN, PA. None.

NEW ORLEANS, LA. None.

NORTH ATTLEBORO, MASS. No means were adopted to check waste of water. All of the consumers are metered and when the service was frozen we removed the meter and placed a nipple in place of the meter and notified the consumer to allow his water to run until we came around and replaced the meter.

QUINCY, ILL. None.

RAHWAY, N. J. None.

RICHMOND, IND. Direct notification by means of circular letters. About 55 per cent of our services are metered, and it is our experience that the principal waste of water to prevent freezing occurs in the smaller and cheaper class of houses, very few of which are now metered.

SAULT STE. MARIE, ONT. Close inspection made by our inspectors, and services discontinued where it is necessary to allow same to run to prevent freezing, as in almost all cases the difficulty is on customer's side, since we use extra precaution in installing our part of the service so as to be safe from frost.

SPOKANE, WASH. None.

STRATFORD, ONT. None.

Streator, Ill. None.
Suffern, N. Y. None.
Walkerville, Ont. None.

To what extent did the waste of water occur in metered services?

Altoona, Pa. No appreciable difference. The consumption was as follows for the entire system:

	gallons
November, 1911	125,475,000
December, 1911	132,481,250
January, 1912	162,063,000
February, 1912 (Estimated)	180,250,000
Per cent of services metered	0.048

Berlin, Canada. Very little above the usual.
Bradford, Pa. Not very large.
Champaign, Ill. Quite considerable.
Dubuque, Ia. Hard to tell.
East Las Vegas, N. M. None.
Hoquiam, Wash. In metered services we think the water is not wasted. About 15 per cent of our consumers are metered. We think the metering of all services will stop waste of water to prevent freezing.
Mobile, Ala. Slight.
New Orleans, La. All services metered. Effect as yet immaterial.
North Attleboro, Mass. All metered services. In all cases the service pipes were frozen from the cellar to the water mains. Where the service was located in a ledge or rocky and loose gravel soil the frost would penetrate much quicker than those located in a clay and loam soil.

Water consumption—100 per cent metered

	gallons
November, 1911	11,258,000
December, 1911	11,467,000
January, 1912 (frozen service)	13,842,000
February, 1912 (frozen service)	15,960,000
January, 1911	12,130,000
February, 1911	12,740,000

Rahway, N. J. We meter only factories, livery stables and stores. Found practically no increase except in stores, where it amounted to 12 per cent.

Richmond, Ind. Not noticeable.

Sault Ste. Marie. None.

Spokane, Wash. Did not keep record.

Stratford, Ont. Cannot determine, at present.

Streator, Ill. Ten per cent.

Walkerville, Ont. Cannot tell.

Mr. J. M. Diven. The questions on the effect of cold weather on water consumption were suggested by an article in *Engineering Record*, by Mr. Dexter Bracket. This article dealt with the effect of freezing weather on the water consumption in the Metropolitan Water District—Boston, and other cities and towns in the vicinity. Mr. Bracket gives the following figures, viz:

	gallons
December, 1911, average temperature, 37°F. Average daily consumption	103,169,000,000
January, 1912, average temperature 19°F. Average daily consumption	139,885,000,000
Increase for January over December	36,176,000,000

Increase for temperature below freezing, 36 per cent.

Per cent of services metered, 45.49.

Further inquiry as to the effect on metered services brought out the following statistics for six completely metered cities:

	PER CAPITA CONSUMPTION					
	Malden	Medford	Watertown	Melrose	Belmont	Milton
December, 1911	43	43	59	62	56	35
January, 1912	50	47	68	65	59	38
February, 1912	51	52	74	83	59	39

These figures show that metering does not entirely stop the waste of water due to cold weather. Householders probably find it cheaper to pay the water department for running water to prevent freezing than to pay the plumber for thawing pipes or putting the plumbing in condition to stand the cold weather. The water department has the consolation of being paid for the waste; though this is rather a poor consolation when the supply is short.

How many meters were lost or damaged by freezing during last winter?

ALTOONA, PA. Lost, 2; damaged, 9.

BERLIN, CANADA. About 100.

BRADFORD, PA. Not over 6 out of every 125.

BUFFALO, N. Y. Very few.

CHAMPAIGN, ILL. Perhaps 250 to 300 out of a total number of 3700.

DUBUQUE, IA. Very few entirely lost. Probably 10 per cent frozen, through negligence mostly, out of 3700 in use.

EAST LAS VEGAS, N. M. None.

ELYRIA, O. Sixty-five out of 3400.

HOQUIAM, WASH. None.

LAKE FOREST, ILL. Eighteen meters were damaged by frost, all but 4 of which were of the breakable bottom type, and were repaired at a very slight cost. Meters of the solid type without the breakable bottom proved themselves to be a very expensive investment and it was also found that repair shops covering this style of meter were so flooded with work that we were unable to have a meter repaired in less than ten weeks. Meters with breakable bottoms were repaired without removing. No meters located in pits were frozen. We use two 24-inch tiles, 2 feet in length with a concrete ring and common catch basin lid for a meter pit where meters are located out doors.

MOBILE, ALA. None.

MONESSEN, PA. Twelve per cent.

NEW ORLEANS, LA. None.

NORTH ATTLEBORO, MASS. None.

QUINCY, ILL. Nine.

RAHWAY, N. J. Fourteen.

RICHMOND, IND. One hundred and fifty.

SPOKANE, WASH. Thirty-one.

STRATFORD, ONT. From 2 to $2\frac{1}{2}$ per cent.

STREATOR, ILL. Twelve.

SUFFERN, N. Y. About 75 of 525.

TOLEDO, O. Approximately 1200 damaged.

WALKERVILLE, ONT. None.

What is the system of setting meters?

Altoona, Pa. Meters are generally set in the cellars of buildings where the conditions are favorable; otherwise they are set in box on sidewalk.

Berlin, Canada. Consumers pay cost of setting.

Bradford, Pa. Meter is furnished free to the consumer by the department, and is installed and kept in repair by the consumer.

Buffalo, N. Y. We furnish the meter and keep it in repair. This work is generally done by our own men. The consumer pays the expense of setting the meter. He also pays for any damage to the meter by frost or hot water, otherwise we keep the meter in repair.

Champaign, Ill. They are set in basement.

Dubuque, Ia. Plumbers do all the setting. Rule is close to the entrance through cellar wall, with stop and waste behind meter, so house can be drained.

East Las Vegas, N. M. Three feet under ground.

El Paso, Tex. Set in concrete boxes made by ourselves not to exceed two feet from surface.

Elyria, O. Basement if possible; in meter well at curb, if not.

Hoquiam, Wash. On business streets we place meters on the service pipe in the sidewalk and encase the same with cement and have a cast iron cover flush with the sidewalk. For domestic use the meter is usually outside of the building, in the lawn, and encased as aforesaid. Meters so set do not freeze in this climate.

Lake Forest, Ill. If there is not a long run of pipe upon the property, meters are set in basement. If the reverse is the case, meters are set in pits located upon the curb.

Mobile, Ala. Meters set in shallow boxes at curb.

New Orleans, La. In boxes on sidewalk.

North Attleboro, Mass. Consumers purchase meter and pay for cost of setting same. Therefore all responsibility rests with consumer.

Quincy, Ill. Nearly all our meters are set in cellars and basements. A wooden box is provided for the meter, and this box is packed full of sawdust for the protection of the meter.

Rahway, N. J. A few set outside under the frost line and covered with manure during cold weather, but mostly in cellars inside of buildings, the latter when possible.

Richmond, Ind. In general the meters are set in cellars, but, where this is not possible, frost-proof boxes are used and set at the curb.

Sault Ste. Marie, Ont. Almost all in basement, a few in manholes.

Spokane, Wash. Consumer applies for meter upon blank form. Our own meter Bureau employees install meter after our own test for accuracy, sometimes in outside supposedly frost-proof box and sometimes in basement. Consumer owns meter and pays cost and cost of installation. If any disorder in meter is due to us we pay for repairs; otherwise, the owner pays.

Stratford, Ont. In cellars. If it cannot be so placed, and must be outside the house, then a complete air chamber, with preferably two top manhole covers, is built to contain it, at the cost of the consumer.

Streator, Ill. In basements and outside boxes.

Suffern, N. Y. Connect with service at entrance to cellar. Always set them upright.

Tampa, Fla. Under our contract with the city, we have a right to charge either a flat rate or a meter rate. In case the company is dissatisfied with a flat rate, it can place a meter on the service and charge by meter consumption. In case the company does this, it will have to pay the cost of the meter and the maintenance of same. If the consumer wishes to take water by meter, he can do so by furnishing his own meter and paying the cost of installing. The company has gone a little further than this. They say to the consumer, if he will pay the cost of the meter and the setting of same, that the company will maintain it thereafter.

Toledo, O. Meters are all set in houses. No outside boxes used.

Walkerville, Ont. In basements or frost-proof wells.

What special precaution or action is taken to prevent freezing of meters?

Altoona, Pa. None.

Berlin, Canada. None.

Bradford, Pa. Placing them where they will not freeze, otherwise require them to be well boxed and covered.

Buffalo, N. Y. Nothing special, but in few cases do pack them in sawdust or straw.

Champaign, Ill. None on part of water company. Consumers own and maintain them.

Dubuque, Ia. Draining out only on excessively cold nights.
East Las Vegas, N. M. None.
Elyria, O. None.
Hoquiam, Wash. None.
Lake Forest, Ill. None.
Mobile, Ala. None.
Monessen, Pa. None.
New Orleans, La. None.
North Attleboro, Mass. All meters are located in the cellar, and in a number of instances in a box packed with straw or sawdust.
Quincy, Ill. Sawdust in meter boxes.
Richmond, Ind. Circular letters.
Sault Ste. Marie, Ont. Necessary to box a few meters.
Spokane, Wash. When exposed to frost action, packed with sawdust.
Stratford, Ont. None, but we use that class of meters that, in case of frost, usually fracture the cast iron cover, thus getting expansion relief, so that the meter proper does not suffer.
Streator, Ill. Pack with sawdust.
Walkerville, Ont. Notifying consumer.

Was consumer or department or company held responsible for damage to meters by freezing?

Altoona, Pa. Consumer.
Berlin, Canada. Consumer.
Bradford, Pa. Consumer.
Buffalo, N. Y. Consumer.
Champaign, Ill. Consumer.
Dubuque, Ia. Work done by water company and charged to consumer at actual cost. Water turned off if bill not paid.
East Las Vegas, N. M. Company owns and repairs all meters.
Elyria, O. Consumer, if set in basement.
Lake Forest, Ill. Consumer.
Monessen, Pa. Consumer.
New Orleans, La. City maintains all meters.
Quincy, Ill. Consumer.
Rahway, N. J. Consumer.
Richmond, Ind. Consumer responsible and pays for damage.

Most of our meters are Lamberts, and of the 150 meters frozen 119 were repaired in the shop, 31 having been sent to the factory on account of damage to the casing. In most cases of damage by freezing in above meters the flanges were spread, which repair could be taken care of in the shop.

Sault Ste. Marie, Ont. Company bears loss under present contract, but we think this should be revised, as consumer should be responsible for safe keeping of meter.

Spokane, Wash. Consumer, if negligent.

Stratford, Ont. So far borne by department who own and locate the meters at their own discretion, so that plumber cannot be blamed if they are not properly located.

Streator, Ill. Company.

Suffern, N. Y. Consumer.

Toledo, O. Consumer.

What charge is made for private fire services?

Altoona, Pa. None.

Bradford, Pa. None, so far as our experience goes.

Buffalo, N. Y. Our charge up to May 1, 1912, was $10 per year. We have had a large amount of trouble with fire lines. This spring a new ordinance was passed, as follows:

"Fire pipe lines or sprinkler connections, fire use only, as approved by the commissioner of public works and of the type approved by the board of fire underwriters in December, 1910 (which approval is on file in the office of the city clerk), will be granted on special request; blue print of system as granted to be filed in the bureau of water, with a good, sufficient bond in the sum of fifteen hundred dollars, conditioned that the applicant, his successors, assigns and lessees shall comply with all the ordinances of the city and the regulations of the department of public works in relation thereto; and the supply to be metered; rate, $24 per annum, in addition to the regular meter rate for all water shown by the meter to have been used, except in case of fire. The provisions of this paragraph shall not apply to outside hose connections on buildings intended for the use of the fire department exclusively."

We do not like the ordinance in its present shape, because it is too expensive and are working on a device that we hope will overcome that expense. Since the new ordinance was passed, we have

been complying with it on all new supplies, except that we have waived the present metering and ask a letter from the consumer agreeing to meter later in any way ordered. On the old supplies we are at present only collecting the $24 per year and sealing such valves as we can.

CHAMPAIGN, ILL. Just considering schedule of rates.

DAYTONA, FLA. No charge is made for private fire service. All property is taxed to maintain the fire protection. Fire lines are installed as far as the curb at cost by the city. The water that is used by private fire lines for extinguishing fires would presumably be taken from the city hydrants were there no private fire line. We therefore consider that the private fire line not only costs the city nothing, but that it actually saves expense for the city, the saving resulting from earlier and therefore better control of the fire, which results in the use of less water and takes less time from the fire department.

DUBUQUE, IA. Varies, but average $50 per year for 1500 sprinkler heads.

EAST LAS VEGAS, N. M. None, but do not see why there should not be a charge.

EL PASO, TEX. Small private fire protection lines, $0.90 to $1.80 per month. Fire hydrant service, more than two on one line, $26.25 per annum each.

ELYRIA, O. None.

HOQUIAM, WASH. Our rates for stand pipes and automatic sprinklers are as follows:

For a pipe of 1 inch diameter or less per month	$0.50
For a pipe of 1½ inch diameter or less per month	1.00
For a pipe of 2 inch diameter or less per month	1.50
For a pipe of 3 inch diameter or less per month	3.00
For a pipe of 4 inch diameter or less per month	4.00
For a pipe of 6 inch diameter or less per month	6.00
For larger pipes, special rates.	

For very large consumers where rates exceed $100 per month it is our custom to make no charge for fire service.

LAKE CHARLES, LA. We charge $10 per month for a 4-inch connection for fire service, and, in addition, charge for whatever water is used. Our customers for this service are mostly saw mills, and the lines are connected to standard fire hydrants placed in the lumber yards and around the mills. Where there are any other connections to the line, we put meters on them.

Monessen, Pa. The minimum charge for sprinkler service where the total value of the buildings and materials protected does not exceed $25,000 is as follows:

For 1 inch Fire service line	$8.00
For 1½ inch Fire service line	15.00
For 2 inch Fire service line	20.00
For 3 inch Fire service line	25.00
For 4 inch Fire service line	35.00

Wherever the value of buildings and materials protected exceeds $25,000, an additional charge is made for such excess in value of property protected, as follows:

For first additional $50,000 or fraction thereof	$0.001 per dollar
For all over $75,000 or fraction thereof	$0.0005 per dollar

Applicants furnish with their applications an estimate of the value of the buildings and materials to be protected, and plan of the proposed pipe lines.

New Orleans, La. All our fire services ought to be metered and to be charged for at exactly the same rates as any other service.

North Attleboro, Mass. None.

Quincy, Ill. We charge $30 each per year for private fire hydrants and 10 cents each per year for each automatic sprinkler head. Both of these charges are subject to a graduated discount, based upon the amount of water used and paid for, for domestic purposes. By this graduated discount, it is possible for the consumer to reduce the fire hydrant charge to $12 each per year, and the sprinkler heads to 4 cents each per year, provided he uses and pays $275 or more per quarter for water.

Rahway, N. J. None.

Richmond, Ind. None.

Sault Ste. Marie, Ont. Some are metered. Also have a flat rate of $25 per year for 2½-inch hose connection.

Spokane, Wash.

Water for private fire protection

	per year
For each 8-inch connection	$36.00
For each 6-inch connection	30.00
For each 4-inch connection	24.00
For each 3-inch connection	18.00
For each 2-inch connection or less	12.00

Municipal rates

For fire protection	$9,000.00
For sewer flushing	3,000.00
For street flushing and sprinkling	5,000.00
For watering troughs, drinking fountains and other municipal purposes	1,000.00

STRATFORD, ONT. None.

STREATOR, ILL. 2-inch, $100; 3-inch, $150; 4-inch $200; 6-inch, $300.

TOLEDO, O. None.

WALKERVILLE, ONT. The following rates will apply to all private fire services, sprinkler systems and stand pipes.

A. Fire hydrants. Connected direct to this company's mains, but installed at expense of applicant.

Per annum, each	$20.00

B. Fire service connections. No connection larger than 6-inch allowed.

6-inch opening off water main, per annum, each	$60.00
5-inch opening off water main, per annum, each	40.00
4-inch opening off water main, per annum, each	25.00

C. Fixtures and connections. Unless the supply is protected by an approved water meter, fixtures and connections are additional as follows:

Fire hydrants, per annum, each	$20.00
Stand pipe hose connections, not over 1½ inch opening:	
The first, per annum	5.00
Second, per annum	3.00
Any additional, per annum, each	1.00
Sprinkler heads.	
The first 1000, per annum, each	0.10
Next 1000, per annum, each	0.075
Any additional, per annum, each	0.05

All the rates shown in A, B and C are subject to the following discounts:

When the domestic or factory consumption amounts to $1000 per annum or over, 100 per cent; $900 per annum or over, 90 per cent; $800 per annum or over, 80 per cent; and so on for each $100 graduation, 10 per cent less discount, until the annual rate amounts to $100 or less, 10 per cent.

Customers wishing to purchase a detector meter, the size of the fire service main, may do so, in which case the annual charge will amount to the service connection charge together with rate governing the by-pass meter. This latter meter will be furnished and maintained by and remain the property of the Water Company. Services thus equipped will not be required to pay on basis of itemized rates quoted above.

Connections supplying domestic or factory requirements, and earning a revenue equal to the minimum charge for such size service, to which are attached stand pipes or sprinkler heads, will be considered "Combination Services," and will not come under the head of "Fire Service Connections" listed in schedule B.

As the discounts on the foregoing rates will be based on the year's consumption, computed from the quarterly meter bills, such rates will be payable on or before the 15th January following.

How are these services controlled or regulated?

Altoona, Pa. A bond of $2000 is required of each person installing a sprinkler system, that they will not make any connections to said sprinkler system except for sprinkler purposes, and if such connections are found, the person so offending will forfeit the said amount. On wall reels or stage lines in theatres, a meter is set.

Champaign, Ill. By meters.

Daytona, Fla. Private fire lines are sealed, a nominal charge is made for resealing and a penalty exacted for dishonest use of water.

Dubuque, Ia. By meters.

East Las Vegas, N. M. No control whatever.

El Paso, Tex. Small lines without control except by attention of inspector. Large lines have by-pass meters.

Elyria, O. Not controlled.

Hoquiam, Wash. Frequent inspection, and if suspected that water is being stolen, meters are placed on the line.

Mobile, Ala. About 75 per cent metered, detector or current type. In future detector meters only will be used.

Monessen, Pa. The company reserves the right to install detector meters at the expense of the consumer, but has not yet done so.

North Attleboro, Mass. No meters on fire services. Inspected every sixty days.

Quincy, Ill. On all new fire services we require installation of a detector meter.

Rahway, N. J. By detector meter.

Richmond, Ind. None are metered, but all valves on private fire services are wired and a tag put on the valves that the company must be notified in case the seal is broken. So far as our inspections indicate, there has been no theft of water from these lines, but we are firm believers in the use of meters on all fire lines, as they are the only sure means of detecting the use of water through these lines.

Sault Ste. Marie, Ont. Meters automatically control those services that are metered. Flat rate services are controlled by inspection only. Detector meters installed where service is strictly for fire purposes and underwriters requirement demand. On all other services where same may be used for other than fire purposes positive displacement meters used.

Spokane, Wash. By valve on pipe in street next to service main. All openings inside property line sealed if service is on flat rate, and resealed after fire. Type of meter depends on class of service.

Stratford, Ont. Current meter at present, but shall probably use detector soon, as the whole subject is under discussion.

Streator, Ill. By valve.

Toledo, O. Services are independent of all other services on the premises and are controlled by independent shut-offs in the street. No meters are used, but the possibility of the use of meters has been contemplated.

When meters are owned by the consumer is a monthly charge made for reading and ordinary maintenance of same? If so, how much annually?

Altoona, Pa. A semi-annual charge of $2 is made for private families and $5 for business and manufacturing concerns.

Champaign, Ill. Minimum of $1.25 per year.

Daytona, Fla. For a while we allowed the consumer to own his meter; $2 per annum was deducted from his minimum annual water bill in view of his ownership of the meter. The minimum

annual charge still contained about $3 above the charge for *water*. This $3 was therefore obviously a charge for reading and maintenance of the meter, and the service. But the meter is a part of the service. It is a part of the fixed assets of the water works. Why then should any patron be allowed to take that much preferred stock in the enterprise, with a definite annual dividend?

Dubuque, Ia. No charge for maintenance except in case of freezing.

East Las Vegas, N. M. Meters owned by water company.

El Paso, Tex. No charge is made for meter service in any respect.

Elyria, O. Maintenance only.

Hoquiam, Wash. Where meters are owned by consumer we make no charge for reading them, but the cost of maintenance in the way of repairs is charged to consumer.

Lake Forest, Ill. Meters are owned by consumer, being read quarterly, ordinary maintenance paid for by consumer.

North Attleboro, Mass. None.

Quincy, Ill. No meters owned by consumer.

Rahway, N. J. No.

Richmond, Ind. Very few meters owned by consumers. No monthly charge made for reading; the company charges consumer for repair of such meters.

Sault Ste. Marie, Ont. None owned by consumers.

Spokane, Wash. Have 80 cents minimum monthly rate, entitling consumer to 8000 gallons.

Stratford, Ont. No charge is made for reading any meter. The factory meters are owned by the firms using them, and repairs are at their cost, or they pay the board a 10 per cent rental on the original cost and the board keeps them in repair.

Streator, Ill. Consumer does not own meter.

Tampa, Fla. The charge made is a minimum of $1.25 per month, and for this the consumer is entitled to a consumption equal to 180 gallons per day or 5400 gallons per month.

Toledo, O. No charge is made for reading and maintenance of meters. The department makes free repairs due to wear on meters, until a meter is judged worthless and then the customer must purchase a new one. Damage to the meter due to cold weather or freezing is charged to the customer.

Walkerville, Ont. None except repair.

When meters are owned by water department or company is a monthly charge made for rent of meter, ordinary maintenance and reading? If so, how much annually?

ALTOONA, PA. Private families, $4; business concerns, $10.

CHAMPAIGN, ILL. A few are on rental. We charge 50 cents per year for $\frac{5}{8}$-inch.

DAYTONA, FLA. The city owns all meters. All services are metered. Since the meter is considered an inseparable part of the service, no so-called meter rental is charged. A *service rental*, however, is charged. It is intended to cover interest and depreciation on the entire service; the ordinary maintenance of the service; the cost of reading meters, billing and collecting water rents; and the value of the water which the average meter fails to register. This service rental for a $\frac{3}{4}$-inch service is $5 per annum. *Water* is 10 cents per 1000 gallons. A consumer's "water bill" is therefore $1.25 per quarter, plus a charge for water consumption at the rate of 10 cents per 1000 gallons.

DUBUQUE, IA. Twenty-five cents per month rental for $\frac{5}{8}$ or $\frac{3}{4}$-inch. Larger in proportion.

EAST LAS VEGAS, N. M. None.

HOQUIAM, WASH. Where a meter has been set by the water company at its own expense no charge is made whatever to the consumer. Where a dissatisfied consumer asks for a meter it has been our custom heretofore to charge a monthly rent of 25 cents for small sizes; but under a recent ruling of the public service commission we are not now permitted to make any charge whatever for the use of a water meter.

LAKE FOREST, ILL. A few meters are owned by the company, for which a rental is charged as follows: $\frac{5}{8}$-inch, $0.63; $\frac{3}{4}$-inch, $1.07; 1-inch, $1.45; 2-inch, $3.40; quarterly.

MONESSEN, PA. Annual rental, $2.50.

NORTH ATTLEBORO, MASS. None.

QUINCY, ILL. Do not make monthly charge for maintenance and reading. Have minimum meter rate of $10 per year on a $\frac{5}{8}$-inch or $\frac{3}{4}$-inch meter and that minimum increases with the larger size meters.

RAHWAY, N. J. Rental $2, $3, $4 and $8 for $\frac{5}{8}$, $\frac{3}{4}$, 1 and 2-inch, respectively.

RICHMOND, IND. A monthly meter rental is charged ranging from 25 cents for domestic use to $2 for larger sizes.

Sault Ste. Marie. No meter rental.

Spokane, Wash. Do not rent.

Streator, Ill. Minimum charge $\frac{5}{8}$-inch meter, $10; $\frac{3}{4}$-inch, $12; 1-inch, $20 annually. Meter rates 8 cents to 30 cents per 1000 gallons.

Tampa, Fla. Do not rent.

Toledo, O. On the few meters owned by the water department no charge is made for rent or maintenance, but the cost of water is doubled, unless the consumer owns his own meter.

What is the best way of increasing the supply from flowing wells 8 inches in diameter? Electric power is available at $30 per horse power for twenty-four hours.

El Paso, Tex. This depends entirely on local conditions, and remedy must be supplied accordingly. In deep wells the air lift system will do the work, especially if sand of any character is to be contended with. If shallow wells, the class of water, pressure required for lift, etc., must be considered.

Lake Charles, La. We are now pumping our wells direct: that is, our pump suction lines are connected to the well casings, and we have a suction line to the bottom of the well. However, we find that our wells flow a great deal more at lower depth; that is, if we dig a pit down around the well, the flow at the bottom of the pit will be much greater than after the pit is filled, the increased height seems to limit very much the natural flow. We are contemplating digging a pit around all of our wells and allowing them to flow into this pit and pumping from the pit. We think that as the pumping demands increase, we will lower the water in the pit, which will allow the wells to flow more, thus making a natural increase when the increase is needed.

New Orleans, La. Should say deep well pumps. Generate your own current if price of current is too high.

Spokane, Wash. Have no wells of this size—ours 30 feet in diameter.

Tampa, Fla. Our experience is that the best way of increasing flow is by application of compressed air.

A deep well water pumped direct developed hydrogen sulphite gas. What is the best way to aërate this water to get rid of the gas?

Daytona, Fla. We are completely eliminating the H_2S gas from water heavily impregnated therewith by the use of aërating fountains. The raw water enters through fountains and is forced to splatter on boards below before passing into the receiving basins.

El Paso, Tex. Know of no plan that will entirely get rid of gas in water while being pumped direct. "Hydrogen sulphite gas" being an unknown quantity a reply to this question would not likely give the information desired.

Lake Charles, La. In pumping our wells direct, we find that there is considerable gas (have made no investigation as to its nature) between the pumps and the standpipe, but that past the standpipe there is none. We presume that the gas is liberated in the standpipe.

North Attleboro, Mass. Hydrogen sulphite gas developed in a deep well (300 feet) connected with a small water works plant in the middle west a few years ago. It was so bad that it was almost impossible to drink and could not be used for cooking purposes. This was overcome by installing or constructing a large concrete basin and a large spray was constructed in the centre of the reservoir. The water pumped from the well would be pumped through this spray and allowed to fall into the reservoir or basin and then pumped to the stand pipe. This method, however, required the handling of the water twice. By this method the water was rendered so it could be used for all domestic uses such as drinking and cooking, etc., and the hydrogen sulphite gas practically eliminated.

Tampa, Fla. By the application of compressed air.

What has been your experience with lead flanged connections in place of wiped joints?

Altoona, Pa. Our experience has been that it is very unsatisfactory.

Champaign, Ill. We are now using lead flanges, never have had one leak. Wiped joints are a lot of trouble.

El Paso, Tex. We use the lead flange connections and have no trouble. Do not use wiped joints of late years, for if not well made are not best for service and are more difficult to repair, therefore more expensive. Flange joints preferable.

Elyria, O. Satisfactory.

New Orleans, La. Have given trouble on account of vibration

due to traffic in our peculiar soil condition and are not being used any more.

North Attleboro, Mass. The lead flange joint has been in use in this water department for the last ten years and to this date not one of them has been removed or has given us any trouble by leakage, etc. By the installation of the lead flange coupling it requires less experienced men to put in a service pipe, otherwise it required an experienced man to make a good tight job with a wiped joint. Furthermore it requires less time to install a service with the lead flange joint than the ones made up with wiped joints.

Quincy, Ill. The lead flange connection seems to make a convenient, firm joint, and is entirely satisfactory.

Rahway, N. J. We use flange connections on our curb cock and wiped joints on goose necks with satisfactory results.

Sault Ste. Marie, Ont. Use nothing but lead flange connections. Consider them much better than the old wiped joints, which we are replacing as fast as they give trouble.

Spokane, Wash. We prefer lead flange.

Tampa, Fla. Lead flange most satisfactory.

Have plumbers objected to the use of lead flanged connections in your city? If so, what has been the outcome; have you discontinued their use on account of such objection?

Altoona, Pa. Plumbers have not objected, but we discontinued the use of them on account of the leaking and bursting of the lead.

Champaign, Ill. Yes, plumbers naturally do not like them, but that made no difference to us. They made no disturbance.

East Las Vegas, N. M. All our plumbers use wiped joints.

El Paso, Tex. Have had no trouble from any source through the use of flange service connections.

Elyria, O. No to both questions.

New Orleans, La. Have discontinued their use for reason above stated.

North Attleboro, Mass. None.

Quincy, Ill. Plumbers have made no serious objections to the use of lead flange connections.

Rahway, N. J. They have offered no objections.

Richmond, Ind. Plumbers have not objected to said connec-

tions, not having used enough of them to judge of the merits or demerits of same.

Sault Ste. Marie, Ont. The company install all services from the main to the curb line (about 9 feet from the property line), average length of service 25 feet which includes an 18-inch lead connection at the main so that outside plumbers have nothing to do with the lead connection but connect directly to the curb cock.

Spokane, Wash. We employ no plumbers on our taps. They are our own employees who use the material we prefer.

Streator, Ill. No.

Tampa, Fla. We have found very little objection from plumbers regarding the use of lead flange connections, and have never, since we began using them, discontinued their use. We have on this plant, in service, between eight and ten thousand of these lead flange joints and have found them very satisfactory.

Mr. W. F. Wilcox: When the speaker was manager at Meridian, Mississippi, we had to put in a great many lead services on account of paving work. Instead of using the corporation cock with the ordinary tailpiece and wiping the joint between the tailpiece and the lead pipe, we used the flanged union to connect the lead pipe directly with the corporation cock.

The plumbers raised quite a disturbance and threatened to enjoin us. The speaker pointed out the fact that even if we used the wiped joint to connect the tailpiece and the lead pipe we would still have the union coupling joining the tailpiece to the corporation cock, and that he could not see any benefit to be derived by putting in an additional joint in the service, even if it were a wiped joint.

The matter was then dropped.

Mr. E. E. Davis: Down our way the plumbers would not use them and would not allow them to be used.

Secretary Diven: The question asks whether the plumbers do object to it and whether their objection makes it impossible to use them.

Mr. Dow R. Gwinn: We are using lead flange couplings not only for the purpose stated but also for curb cocks. Do not remember over two cases in eleven years of our having had trouble from lead flanges. Think a flange joint is far better than a wiped joint.

If we can furnish something better than the plumbers can furnish it would be very foolish not to use them simply because somebody objects to them. Do not see any reason why a man cannot use a thing if it answers the purpose better and at less cost.

SECRETARY DIVEN: Will state the question more broadly. The member suggesting the question said that the plumbers' union condemned them and refused to do plumbing in the houses where they had been used.

MR. W. F. WILCOX: Mr. Worrell has 5000 that were put in at one time. Think he is in pretty good shape to tell you something about them.

MR. M. L. WORRELL: The speaker has had a good deal of experience with them at Rome, Georgia, where there were put in about 1600 and we did not have any trouble with them at all. At Meridian, Mississippi, since he has been there, about a year and a half now, we have had two in trouble. Two out of 500 or 600 is pretty good. He will say, however, that personally he prefers the wiped joints; though he is not opposed to the flange joint.

MR. LEONARD BAUER: The speaker has had some experience with them. He concluded to make some changes in the employees of the water works department when he was immediately called upon by master and journeyman plumbers who objected to his having a man put in service branches, who had had fifteen or more years' experience in the water works, but who was not recognized as a plumber, although he could do the work. We paid no attention to their complaint but went right ahead and told them that we proposed to use our own judgment in the matter. The controversy got pretty warm but we managed our men to suit ourselves and got flange joints, and we are using them to perfect satisfaction. They made no trouble after that and the complaints died a natural death.

MR. E. E. DAVIS: It was either the speaker's good fortune or misfortune to have served an apprenticeship in plumbing before he started in the water works business, and when he was serving his apprenticeship everything had to be wiped joints. So he is one of the older plumbers, but he has always been ready to take up any

new improvement. His inclination, of course, is naturally toward the trade that he first learned, and whenever he employs a plumber and finds that he can not wipe a joint he discharges him. His preference is for wiped joints, because he knows if properly wiped they are all right. He believes that an expert plumber can wipe two joints while he is putting one of those couplings on.

OBITUARY

Resolved, That the association notices, with keen regret, the loss by death of three of its members, Charles A. Hague, Fred Litterer and J. M. Wisler, during the year just past, and extends its sympathy to the close associates and relatives of those who have passed away. The association feels deeply the loss of these valued members, and will cherish their memory for their good works, which are their best monument.

Mr. Chas. A. Hague died in New York City, New York, on the twenty-sixth day of June, 1911. At the time of his death Mr. Hague was practicing as a civil and mechanical engineer, with his office in New York City, New York.

Mr. Hague had had a very wide and successful experience in connection with water works engineering, and was especially expert in the mechanical problems pertaining to pumping machinery. His first work in water works engineering was in connection with surveys for a gravity system of water supply from Lake Charlotte, for the city of Hudson, New York. Following this work he entered the employ of the Clapp and Jones Manufacturing Company, builders of steam fire engines and pumping machinery, eventually becoming their chief draftsman, and assisted in the designing of the original fire boat pumps for New York, Brooklyn, Chicago, and other cities. Later, Mr. Hague was, for about four years, connected with the Allis-Chalmers Company, engaged in the tests and experiments which led to the design of the vertical, triple expansion pumping engines, which are now so prominent in the best water works practice. Mr. Hague then spent two years in the service of the Geo. F. Blake (pump) Company, and seven with the Henry R. Worthington Company, being identified during these years with the installation of pumps of various types and large capacity in many of the principal cities of the country. As a consulting engineer Mr. Hague had subsequently been connected with many important projects in civil and hydraulic engineering work, including the design and construction of dams, reservoirs, water distribution systems and pumping plants, and the testing, etc., of pumping and

other machinery. He was also the author of an important book, entitled *Pumping Engines for Water Works*, and was considered a high authority on this subject. He was also frequently called upon to act as an expert witness in cases requiring technical interpretation pertaining to water supply or power. Among the cities which he served as consulting engineer in some of these capacities in important cases were Trenton, New Jersey; Lockport, New York; Bradford, Pennsylvania; Reading, Pennsylvania; Ogdensburg, New York; Harrisburg, Pennsylvania; Boston, Massachusetts, and Philadelphia, Pennsylvania.

Together with his own work Mr. Hague always found time to take an active and helpful part in the various technical societies and associations of which he was a member, and to keep abreast of the times in the general line of the works in which he was interested. He was a valued and active member of the following societies, viz: American Society of Civil Engineers, American Society of Mechanical Engineers, New England Water Works Association, and the American Water Works Association.

Mr. Fred. Litterer, chief engineer of the water works of Decatur, Illinois, was killed July 26, 1911, by the falling of a derrick at the new water works dam, the construction of which he was superintending. Mr. Litterer was about fifty years of age. He was of German descent, and possessed the characteristic thoroughness of that nationality. He was a machinist of many years' experience, and had been for a number of years identified with the machine shop of the H. Mueller Manufacturing Company, when about fifteen years ago he was selected as chief engineer of the Decatur Water Works. Mr. Litterer had made a study of water works pumping machinery, and his mechanical knowledge and ability as a machinist rendered his service to the city most valuable both in ordinary operation and in the reconstruction of the water works plant, which took place during his incumbency. He took great pride in the proper maintenance of the plant, and in explaining its workings to any who were interested therein, since he recognized the rights of the taxpayers to be interested in their water works plant, and this recognition contributed much to the personal popularity and confidence which he obtained.

Mr. J. M. Wisler, superintendent of water works of Toledo, Ohio, was killed on September 4, 1911, together with six other water works and other city officials who were together in a motor boat and were run down by a lake tug. Mr. Wisler was born in Indiana in 1861. After completing his education he taught school for several years, and then learned the trades of machinist and boiler maker, serving under his father, who was a skilled machinist. Subsequently, he served as machinist in the Baltimore and Ohio Railroad shops at Garret, Indiana. From 1888 to 1896 he was in business on his own account as a machinist. From 1897 to 1902 he was chief engineer of the Toledo and Ohio docks, and later he was employed in a responsible position with the Brown Hoisting Company, and following this was master mechanic for the Toledo Terminal Railroad shops, which position he resigned in 1906 when he was appointed as superintendent of the city water works of Toledo.

SUBJECT INDEX

Air chamber, on pipe lines..... 322
rule for size of..... 322
on elevator supply pipes, to absorb shock..... 319
Alkaline soil conducive to electrolysis..... 297
Altoona, Pa., breaking of private fire services at..... 360
action when mains frozen..... 396
bursting of frozen mains..... 400
bursting of frozen services..... 400
charge for private fire services..... 411
charge for reading and maintaining meters owned by consumer at... 416
charge for reading and maintaining meters owned by waterworks at. 418
checking cold weather waste at..... 404
cold weather waste of metered water at..... 405
control of private fire services at..... 415
depth of frost at..... 389
effect of cold weather on water consumption at..... 402
experience with lead flanged connections at..... 420
frost below ordinary at..... 390
frozen water mains at..... 390
meters damaged by freezing at..... 407
methods of prevention of freezing at..... 391
regulation of private fire service at..... 360
responsibility for freezing meters at..... 410
thawing hydrants at..... 397
thawing services at..... 398
American cities, consumption of water in, compared with British cities.. 249
water consumed in for business uses..... 250
water consumption in..... 247
American Water Works Association, original call for..... 54
Anchor ice, how and when formed..... 302
stones floated by..... 320
Ancient aqueducts, Alsietinus at Rome, A. D. 10..... 6
Anio Novus at Rome, A. D. 38–52..... 8
The Appian, B. C. 312..... 4
At Patria in Syria..... 2
Aqua Anio Vetus, B. C. 272–269..... 4
Aqua Julia at Rome, B. C., 125..... 6
Aqua Marcia, B. C., 144–140..... 4
Aqua Tepula at Rome, B. C. 125..... 6
Claudia at Rome, A. D. 38–52..... 6
Hadriana at Rome, A. D. 109..... 12
In Asia Minor..... 1

Ancient aqueducts, in Greece 2
Laodicea in Phyrgia 1
Trajana at Rome, A. D. 109 9
Virgo at Rome 6
Ancient and Modern Water Works. Paper by Edward Wegman 1
Anode-electrode by which current enters 160
Appian Aqueduct, B. C. 312 4
Aqua Julia at Rome, B. C. 125 6
Aqua Tepula at Rome, B. C. 125 6
Aqueducts Anio Novus at Rome, A. D. 32–58 8
Anio Vetus, B. C. 272–269 4
Appian at Rome, B. C. 312 4
Aqua Marcia, B. C. 144–140 4
Aqua Tepula at Rome, B. C., 125 6
At Laodicea in Phyrgia 1
at Patria in Syria 2
built by Romans in other countries 16
Claudia at Rome, A. D. 38–52 6
construction in tunnel at Rome 14
Aqueducts, construction of early Roman 14
Hadriana at Rome, A. D. 109 12
in Greece 2
Julia at Rome, B. C. 125 6
Alsietinus at Rome, A. D. 10 6
Pia at Rome, A. D. 1860–1870 20
Primitive means of leveling in 12
Trajana at Rome, A. D. 109 9
Virgo at Rome, B. C. 19 6
use of lead in 12
Ashokan Reservoir, capacity of 130,000,000,000 gallons 32
commenced in 1905 27
Asia Minor, water works in 1
Atlanta, Ga., charge for private fire service at 366
control at private fire service at 366
Atlantic City, crossing of streams with force main at 315
forty-eight inch wood stave force main for 313
history of water department of 313
Auburn, N. Y., depreciation charge at 329
B. coli: A reliable presumptive quantitative test for 307
abundance of, criterion of sewage pollution 307
need of reliable quantitative analysis for 307
table of results of tests for 308
test of culture media to determine quantity of 307
Bacteria, reduction of by hypochlorite treatment at Kansas City 232
reduction of by water softening process 215
Bacterial results not sought in operation of sewage purification plant 285
Baltimore, Md., regulation governing private fire service in 371
Bays, with marsh shores less in liability of nuisance from sewage 275
Bays and sounds for sewage disposal 275

Berlin, Canada, action taken when mains frozen..... 396
checking cold weather waste..... 404
effect of cold weather on water consumption..... 402
injury from breaking of private fire services at..... 360
meters damaged by freezing at..... 407
responsibility for freezing meters at..... 410
success of municipal ownership at..... 349
system of setting meters at..... 408
thawing hydrants at..... 397
thawing services at..... 398
waste of water to prevent frozen hydrants..... 403
Beyer, A. H., assistant engineer construction of Muskogee settling basins. 189
Boards of Health, lack of proper appropriations responsible for poor work of..... 284
Boiler Plant, annual charges against.....118–123
Bonding, of rail joints of electric railways..... 163
Bonding, size copper wire required for..... 163
Bookkeeping, discussion on municipal..... 331
Boonton, N. J., results of operation of hypochlorite sterilization plant at. 235
Bradford, Pa., action when mains frozen..... 396
bursting of frozen services at..... 400
charge for private fire services at..... 411
damage to meters by freezing at..... 407
depth of frost at..... 389
effect of cold weather on water consumption at..... 402
injury from breaking of private fire services at..... 360
frost below ordinary at..... 390
frozen water mains at..... 390
means of prevention of freezing at..... 391
precautions to prevent meters freezing at..... 409
regulation of private fire services at..... 359
responsibility for freezing meters at..... 410
success of municipal ownership at..... 349
system of setting meters at..... 408
thawing hydrants at..... 397
thawing services at..... 398
British cities, consumption of water in, compared with American cities.. 249
water consumption in..... 248
Brooklyn, description of first pumping engine..... 49
first water works designed by James P. Kirkwood..... 49
first water works engine for, built at Hartford..... 49
water supply of..... 26
Brush, William W., designer of delivery system, New York water works. 35
Buffalo, N. Y., action when water main frozen..... 396
bursting of frozen mains at..... 400
bursting of frozen services at..... 400
charge for private fire services at..... 411
checking cold weather waste at..... 404
depth of frost at..... 389

Buffalo, N. Y., effect of cold weather on water consumption at..... 403
effect of freezing on various kinds of services at..... 401
frost below ordinary at..... 390
frozen water mains at..... 390
injury from breaking private fire services at..... 360
intake crib at..... 301
life of centrifugal pump at..... 133
ice troubles at..... 301
meters damaged by freezing at..... 407
method of preventing freezing at..... 391
precaution to prevent meter freezing at..... 409
purchase of coal by B.t.u. at..... 351
regulation of private fire services at..... 359
responsibility for freezing meters at..... 410
success of municipal ownership at..... 349
system of setting meters at..... 408
thawing hydrants at..... 397
thawing services at..... 398
water supply of..... 301
Burr, Prof. William H., expert on New York water supply 1902..... 27
Byram River, added to New York water supply in 1880..... 24
Calyx, for measuring domestic water supply..... 14
Cast iron, electrical resistance ten times that of wrought iron or steel .. 169
Cast iron main at Atlantic City..... 314
Cast iron pipe, fluctuation in prices of..... 51
history of manufacture of..... 51
some contract lettings for..... 57
substitutes for on account of high price..... 52
western association of manufacturers of..... 52
Cathode, electrode by which current leaves..... 160
Catskill Aqueduct commenced in 1905..... 27
consists of..... 27
cost of..... 33
tunnel under Hudson River..... 32
terminal of..... 32
Catskill Mountains, source of new supply for New York..... 27
Catskill Water Works, commenced in 1905..... 27
Centrifugal Pumps at Buffalo, N. Y..... 133
cause for wearing out a Buffalo, N. Y..... 134
for low lift..... 138
for large capacity and high head..... 137
for low heads..... 135
for low head at Lancaster, Pa..... 135
for small plant..... 139
repairs to at Buffalo, N. Y..... 134
turbine driven, for water works service..... 117
at Richmond, Va..... 137
Champaign, Ill., bursting of frozen services..... 400
charge for reading and maintaining meters owned by consumer at... 416

Champaign, Ill., charge for reading and maintaining meters owned by water works at. 418
checking cold weather waste at. 404
cold weather waste of metered water at. 405
control of private fire services at. 415
depth of frost at. 389
effect of cold weather on water consumption at. 402
experience with lead flange connection at. 421
frost below ordinary at. 390
frozen water mains at. 390
meters damaged by freezing at. 407
method of preventing freezing at. 391
precaution to prevent meter freezing at. 409
responsibility for freezing meters at. 410
system of setting meters at. 408
thawing services at. 398
waste of water to prevent hydrant freezing at. 403
Chicago, Ill., cost of pump leaks at. 245
cost of saving water in. 263
water consumption in. 254
Chlorination at Cleveland, Ohio. Paper by D. D. Jackson. 219
Chlorination at Cleveland, Ohio, cost of plant for. 219
cost per million gallons. 220
quantity used. 220
Chlorination, description of Cleveland, Ohio, plant for. 220
disagreeable taste and odors from, at Cleveland. 219
effect of temperature on. 221
use of compressed liquefied chlorine for. 220
chlorine, compressed liquid for water sterilization. 220
Cincinnati, Ohio, double overhead trolley at. 181
first water works designed by James P. Kirkwood. 49
City refuse, classes of. 357
power from. 351
Clark, William G., on use of hypochlorite at Toledo, Ohio. 243
Cleveland, Ohio, chlorination plant at. 219
depreciation accounting in. 334
description of chlorination plant at. 220
effect of four mile intake on typhoid rate at. 222
periods of infection of water supply of. 219
typhoid at, due to water and to sanitation. 238
use of compressed liquefied chlorine. 220
Coal, cost of. 132
purchase by B. t. u. 351
Coal Mine Operators Association, work of. 317
Committee, suggestions for on classification of rates. 251
Concrete, damp, an electric conductor. 163
for settling basins. 93
life of reinforced dams. 109
physical properties of plain. 93

Concrete, physical properties of reinforced 94
reinforced vs. plain 93
specifications for reinforced settling basins 113
waterproofing compounds for 110
waterproofing not essential for reinforced 94
watertightness of reinforced 94
Concrete dams, leaks due to capillary attraction in 111
Conduits, ancient in Asia 1
Conservation of water, importance of 263
Constantinople, Roman aqueduct at 20
Consulting engineer, importance of in designing sewage disposal plants .. 271
Contamination of water supply by joint fire services at Rockford, Ill 380
Continuous settling basins 89
operation of 91
Copper sulphate, as an electrolyte 160
Corrosion, at joints on pipe line, caused by high resistance joints 168
by electrolysis where current leaves pipes 167
caused by salt water 181
loss of weight of iron caused by, one ampere in one year 161
loss of weight of lead caused by, one ampere in one year 161
not caused by electrolysis 180
produced by low density current 167
where caused by electric currents 167
Cost of Leaks: Does it Pay to Stop Them? Paper by Edward S. Cole 245
Cost, comparative operating of reciprocating and steam turbine driven pumps 120
Cross, Dr. W. N., city chemist of Kansas City, Mo 225
investigation of hypochlorite sterilization by 225
Croton aqueduct, capacity of 400,000,000 gallon 27
the first built in 1842 21
second built 1884–1891 24
syphons under Harlem River on new 24
Croton dam, the first 1842 21
Croton water shed, available storage on 26
storage reservoirs on 26
water supply of 310,000,000 gals. day 27
Croton water supply, in service 1842 24
Croton water works, first constructed 1837–1842 21
Current Measurements on Pipes—best method of connections for 171
Bristol recording instrument for 174
permanent connections for 171
plotting of 172
simultaneous measurements of 173
table for computing currents 197
twenty-four hour records identify source of current 175
Dams, joints in concrete 111
life of reinforced concrete 109
material for watertight joints in concrete 111

Daytona, Fla., charge for private fire services at..... 412
charge for reading and maintaining meters owned by the consumers at 416
charge for reading and maintaining meters owned by the water works at..... 418
control of private fire services at..... 415
Depreciation, a local issue..... 328
amortization considered in accounting for..... 339
charge for at Auburn, N. Y..... 329
charge of renewals to.....333, 335
computing future..... 326
computing past..... 326
discussion on..... 325
earning capacity of depreciated plant..... 326
effect of maintenance on..... 328
few water works can allow two per cent..... 330
inaccuracy in accounting for..... 328
making good in lump sum..... 325
matters under advisement by committee on..... 325
must be determined for each case..... 346
must be earned..... 330
not matter of bookkeeping only..... 330
positive rules cannot be established for..... 342
taking cost of extensions from fund..... 328
two per cent charged off for..... 329
variation of, on pipe in different locations..... 328
Direct current lighting system, no stray currents from..... 162
Discussion, on continuous settling basins..... 109
on depreciation and comparison of rates and bookkeeping methods of municipally and privately owned water works..... 325
on electrolysis from railway currents..... 198
on fifty years reminiscences on water works..... 55
on floor area consumption..... 42
hypochlorite sterilization..... 232
on mechanical principles on reinforced concrete..... 109
on organization of New York Water supply..... 74
on philosophy of purchasing supplies..... 80
on steam turbine driven centrifugal pumps..... 142
on water softening at Owensboro, Ky..... 218
Distribution leaks, classification of..... 245
Double overhead trolley complete remedy for electrolysis..... 181
is used at Washington, D. C., Cincinnati, O., and Havana, Cuba.... 181
Dresser insulating joint..... 186
Drainage system for electrolysis dangerous to other underground structures..... 183
Drainage system of preventing electrolysis..... 182
Dubuque, Iowa, action when mains frozen at..... 396
bursting of frozen mains at..... 400
bursting of frozen services at..... 400
charge for private fire services at..... 412

Dubuque, Iowa, charge for reading and maintaining meters owned by consumer at.... 416
charge for reading and maintaining meters owned by water works at 418
control of private fire services at.... 415
depth of frost at.... 389
effect of cold weather on water consumption at.... 402
effect of frost on various materials in services at.... 401
frost below ordinary at.... 390
frozen water mains at.... 390
injury from breaking of private fire services at.... 360
meters damaged by freezing at.... 407
method of preventing freezing at.... 391
precautions to prevent meter freezing at.... 410
regulation of private fire service at.... 359
responsibility for freezing meters at.... 410
thawing hydrants at.... 397
thawing services at.... 398
system of setting meters at.... 408
Dutchess County, New York, act prohibiting taking water from.... 27
Duties of pumping engines.... 132
Dynamite, use of for breaking large pipe.... 321
East Las Vegas, New Mexico, action when mains frozen at.... 396
bursting of frozen mains at.... 400
bursting of frozen services at.... 401
charge for private fire services at.... 412
charge for reading and maintaining meters owned by consumer at.... 417
control of private fire services at.... 415
depth of frost at.... 389
frost below ordinary at.... 390
frozen water mains at.... 390
injury from breaking private fire services at.... 360
method of preventing freezing at.... 391
regulation of private fire services at.... 359
responsibility for freezing meters at.... 410
thawing services at.... 398
system of setting meters at.... 408
East Orange, N. J., Charge for private fire services at.... 370
how meter system was accomplished at.... 265
water consumption at.... 256
Edmonton, Alberta, character of soil of.... 293
cost of operation of water works at.... 291
history of water supply of.... 290
phenomenal growth of water works of.... 289
statement of increase of business of water works of.... 291
use of ditching machines at.... 292
water mains and sewers laid in lanes or alleys at.... 293
what and where it is.... 289
Efficiency, aided by use of common sense.... 84
altruistic principles of.... 282

Efficiency, by maintaining discipline..... 84
effect of politics on..... 84
ideals of..... 82
importance of planning and dispatching in..... 86
principles of applied to water works..... 81
records reliable, immediate and adequate necessary for..... 85
rewards for..... 85
secured by competent counsel..... 84
standard conditions needed for..... 87
standards for..... 86
standardized operations needed to obtain..... 88
written standards to obtain..... 88
Emergency records, use of..... 87
Egypt, water works in..... 1
El Paso, Tex., charge for private fire services at..... 412
charge for reading and maintaining meters owned by consumer at... 417
control of private fire services at..... 415
depth of frost at..... 389
experience with lead flange connections at..... 421
injury from breaking of private fire services at..... 360
regulation of private fire services at..... 359
system of setting meters at..... 408
Electric currents, through ground..... 166
conveyed by water pipes..... 164
effects on underground piping..... 166
of low density cause electrolysis..... 167
only harm pipes where they leave them..... 167
potential loss in rails cause of..... 166
sources of..... 161
underground structures most liable to injury from..... 167
Electric motors, used for operating Kansas City hypochlorite plant..... 230
Electric railways, bonding of rails..... 162
cause of electrolysis of pipes..... 162
conductivity of bonds..... 163
conductivity of rails and bonds..... 163
connection to generator..... 163
course of electric current..... 163
direct current usually used for..... 162
welded rails for..... 163
Electricity, current required to thaw water mains..... 396
current and time to thaw pipes with..... 398
for thawing frozen mains..... 396
thawing services with at North Attleboro, Mass..... 399
Electrolysis, appearance of pipe not changed by..... 168
best method of connections for measurements for..... 171
Bristol recording instrument for measurement for..... 174
bonding pipes to rails to reduce..... 182
by current shunting from one pipe system to another..... 168
caused by high resistance joints on pipe lines..... 167

Electrolysis, caused by services crossing telephone conduit..... 179
cement jointed pipe not immune from..... 186
classes of methods for minimizing..... 182
corrosion not caused by..... 180
current injures pipe only where it leaves it..... 173
damage by not confined to positive districts..... 178
damage and danger from stray electric currents on pipe..... 178
danger from lessened by stone ballasted tracks..... 184
damage from measured by current between ground and pipes..... 176
definition and theory of..... 159
destroys lead sooner than iron services..... 296
did not affect lead same as iron at Edmonton, Alberta..... 294
double overhead trolley remedy for..... 181
drainage system of preventing..... 182
drop in current causes less current on cast iron than on wrought iron or steel..... 169
drop in volts divided by resistance in ohms gives current in amperes. 171
earth ammeter for measurements for..... 176
earth ammeter used for measurement of current between ground and pipes..... 176
effect of character of soil on..... 297
effect on iron..... 168
first step in survey for..... 169
from alternating currents..... 199
from electric railways using tracks for return conductors..... 162
high resistance joints for preventing..... 184
how to find current flowing on pipes..... 171
identity of current established by recording earth ammeter..... 176
in "negative districts"..... 200, 201
instrument used in survey for..... 169
insulated return circuit only complete remedy for..... 181
insulated track feeders best method to minimize..... 191
intervals in reading in test for..... 169
iron affected by can be cut with ordinary knife..... 168
iron destroyed by same with cast iron wrought iron and steel..... 169
leaks caused by not always apparent..... 168
lessened by removing ground connections of negative bus-bar..... 194
leaves iron with consistency of hard graphite..... 168
loss of metal by..... 161, 167
measurements of current flow on pipes essential..... 177
measurement of current through ground..... 176
measurement of drop to indicate existence or direction of current flow 171
minimized by radial track return feeders..... 194
most damage to service pipes crossing trolley rails..... 169
"mules" as preventive of..... 299
necessity of good connections in measurements for..... 171
non-polarizable electrode for measurement for potential differences.. 175
not caused by alternating currents..... 201
not caused by electric rails above ground..... 163

Electrolysis, not caused by electric railways on wood ties above ground.. 181
not caused by elevated electric railways with rails insulated from structure..... 181
not produced by alternating current lighting systems..... 162
not produced by direct current lighting systems..... 162
not produced by telephone and telegraph currents..... 161
occurs where current leaves pipe..... 160
of wrought iron or steel pipes, leave iron oxide in soil..... 168
paints and dips for preventing..... 184
Peoria case..... 195
permanent connections for measurements for..... 172
pipe drainage to prevent, not good practice..... 202
pipe affected by smooth on bottom..... 299
pipe near power station highly positive to rails..... 170
pipes distant from station negative to rails..... 170
pitting on wrought iron or steel pipes by..... 168
pipes should be examined and tested where current is found to leavé them..... 177
possibility of reducing by insulated return feeders..... 189
plotting of drop measurements..... 172
plotting potential measurements made in survey for..... 170
potential differences not conclusive evidence of..... 170
prevented by insulated third and fourth rails..... 181
prevented by insulating all joints..... 185
railway companies should assume expense and responsibility of preventing..... 195
reduction of by negative feeders..... 190
relief from by special measures..... 187
remedial measures for..... 181
return feeder system for equal drop..... 189
resistivity of cast iron ten times wrought iron or steel..... 169
salt water causing current to leave pipe..... 178
second step in survey for..... 171
simultaneous measurement for..... 173
sources of currents producing..... 161
stray currents a fire hazard..... 179
survey connection to service pipes..... 169
surveys as proof of damage by..... 177
surveys determine where current leaves pipes..... 177
surveys for..... 169
test hammer examination required to establish..... 169
troubles from at Richmond, Va..... 299
twenty-four hour records identify source of current..... 175
unreliability of iron rod electrodes..... 175
use of electric conduit for insulating service pipes to prevent..... 294
use of electrical drains to lessen injury from..... 200
use of fiber conduit to protect services from..... 296
use of non-polarizable electrode in measurements for..... 176
use and value of surveys for..... 177

Electrolysis, usefully applied in the arts..... 159
voltage required to produce corrosion by..... 161
voltmeter readings not a good measure of..... 177
Electrolysis from Stray Electric Currents. Paper by Albert F. Ganz..... 159
Electrolytic conduction, explanation of theory of..... 159
Electrolytic conductor, composed of salts in water..... 159
Electromotive force, how produced..... 161
Elevator indicators, do not account for leaks..... 319
experiences with..... 318
unreliability of..... 318
Elevators, indicators for measuring water used by..... 318
not right to supply water for hydraulic..... 320
trouble from recoil..... 319
use of hydraulic discouraged by metering..... 320
Elyria, Ohio, charge for private fire services at..... 412
charge for reading and maintaining meters owned by consumer at..... 417
control of private fire services at..... 415
depth of frost at..... 389
effect of frost on services of various material at..... 401
experience with lead flange connections at..... 421
frost below ordinary at..... 390
frozen water mains at..... 390
injury from breaking private fire services at..... 360
meters damaged by freezing at..... 407
method of preventing freezing at..... 391
regulation of private fire services at..... 359
responsibility for freezing meters at..... 410
thawing services at..... 398
system of setting meters at..... 408
Endo's medium, for quantitative test for B. coli..... 307
preparation of..... 307
use of in B. coli tests..... 310
Esopus Creek, supply from..... 333
Experiences..... 317
Experiences with elevator indicators..... 318
Filtration, effect of with coagulant on hypochlorite treatment..... 243
occasional failure of plants..... 280
Fire services, approval of chief of fire department of private..... 363
charge for based on insurance..... 377
charge for at Rome, N. Y..... 366
charge for private..... 361, 387, 411
charge for private at Atlanta, Ga..... 366
at East Orange, N. J..... 370
at Memphis, Tenn..... 369
at Meridian, Miss..... 366
at Newport, Ky..... 267
charge for private on minimum meter rate basis..... 377
charges based on size of service..... 377

Fire services, charges for private based on cost of private supply 383
charges for private on number of sprinkler heads..... 377
consideration of charge for private, by Wisconsin public service commission..... 374
contamination of Rockford, Ill., water supply by private..... 380
crippling of service by breaking of private..... 360
how private controlled..... 45
indicator posts on private..... 362
insurance demand for excessive size..... 365
limit of size of private..... 364
limit of size of at Richmond, Va..... 368
at Terre Haute, Ind..... 388
meters on private at Richmond, Va..... 367
no stealing from in Baltimore..... 374
penalty for misuse of private in Baltimore, Md..... 373
rates for private fixed by Wisconsin public service commission..... 364
regulation of private..... 359
regulations governing private at Baltimore, Md..... 371
size of private limited by size of main..... 378
wrongful use of water from private..... 384
Fire setting, for rock excavation..... 14
Floor area basis, illustration of usefulness of..... 40
reasons for adopting..... 86
uses of..... 40
Floor area consumption, effect of power plants on..... 44
effect of steam plants on..... 44
how determined..... 38
in different character of buildings..... 43
Floor Area Unit as a Basis for Estimating Consumption. Paper by William W. Brush..... 35
Floor area of buildings, how obtained..... 36
Force main, wood stave for Atlantic City..... 313
Forty-eight inch wood stave force main built for the water department at Atlantic City..... 313
Frazil ice, forms only in swift running streams..... 302
Freeman, John R., engineer on New York water supply, 1902..... 27
Frontinus, Sextus Julius, curator Rome water supply..... 8
description of Rome water works by..... 9
estimate of water flow by..... 16
gaging of aqueduct by..... 9
Gettysburg, Pa., hypochlorite treatment at..... 233
Ground, conductivity of as compared with iron..... 164
when dry does not conduct electricity..... 160
containing salts and moisture as a conductor..... 160
does not conduct metallically..... 160
Haber, inventor of earth ammeter..... 176
inventor of non-polarizable electrode..... 175
Hague, Charles A., cost of pumping engines..... 128
obituary notice..... 425

Harrisburg, Pa., typhoid statistics..... 238
Havana, Cuba, double overhead trolley at..... 181
Health departments, duty of to enforce use of public water supply when filtered..... 242
should have power to enforce use of pure water..... 242
Health statistics, responsibility of health department for..... 242
Herring, Rudolph, engineer in New York water supply 1902..... 27
High bridge on first Croton aqueduct..... 24
High pressure fire services system of New York..... 66
under control of bureau of water supplies..... 65
Hoquiam, Wash., bursting of frozen mains at..... 400
bursting of frozen services at..... 401
charge for private fire services at..... 412
charge for reading and maintaining meters owned by consumer at... 417
charge for reading and maintaining meters owned by water works at 418
checking cold weather waste at..... 404
cold weather waste of metered water at..... 405
control of private fire services at..... 415
depth of frost at..... 389
effect of cold weather on water consumption at..... 402
effect of freezing on services of various material..... 401
frozen water mains at..... 390
injury from breaking of private fire services at..... 360
method of preventing freezing at..... 391
regulation of private fire services at..... 359
system of setting meters at..... 408
Hose couplings, adoption of standard by Springfield, Mass..... 142
by St. Louis, Mo..... 142
cities that have adopted standard..... 143
conversion of non-standard..... 141
cost of change to standard at Springfield, Mass..... 142
at St. Louis, Mo..... 142
number of cities adopting national standard for..... 141
progress in adoption of national standard..... 141
use of standard, with 7 and 8 thread couplings..... 144
House to house inspection, more objectionable than meters..... 266
Hudson River, aqueduct tunnel under..... 32
Hydrants, crude oil to prevent freezing of..... 394
denatured alcohol to prevent freezing..... 398
discussion on proper size of fire..... 322
discussion on spacing of fire..... 323
manure to prevent freezing of..... 394
salt, oil and alcohol to prevent freezing..... 395
Hydrant fittings, progress in adopting national standard for..... 141
Hypochlorite, cause of tastes and odors from use of..... 243
causes taste and odor when CO_2 not present in treated water..... 243
Hypochlorite plants, use of reinforced concrete in..... 226
Hypochlorite Sterilization at Kansas City, Missouri. Paper by S. Y. High..... 225

Hypochlorite sterilization, alone and with sedimentation or filtration.... 234
available chlorine used at Kansas City..... 230
cost of at Kansas City..... 231
description of Kansas City plant for..... 226
history of, Dr. J. L. Leal..... 233
Kansas City plant operated by electric motors..... 230
results of, at Boonton, N. J..... 235
results of, at Little Falls, N. J..... 235
unsatisfactory results due to improper construction or unskilled operation..... 234
with sedimentation at Omaha and Kansas City..... 236
Hypochlorite treatment, results of, at Little Falls, N. J..... 236
Ice, anchor, how and when formed..... 302
dams caused by anchor and frazil..... 303
frazil in swift running streams..... 302
how cleared at intake, Buffalo, N. Y..... 303
troubles caused by, at Buffalo, N. Y..... 303
Ice Troubles at Buffalo, N. Y. Paper by Henry L. Lyon..... 301
Inspection, effect of house to house, on leaks..... 254
house to house more objectionable than meters..... 266
money spent for house to house better used for metering..... 262
success of house to house in Wilmington, Del..... 263
Insulating joints for prevention of electrolysis..... 186
Intake crib at Buffalo, N. Y..... 301
Ions, acid negative..... 160
definition of..... 160
metal positive..... 160
Iron, amount corroded by one ampere in one year..... 161
Jackson, Miss., experience with lead services at..... 296
Jamestown, N. Y., experience with private fire service..... 363
Jersey City, N. J., quantity of chlorine used at..... 220
Jerusalem, water supply of..... 1
Kansas City, Mo., description of water supply of..... 225
hypochlorite sterilization of water supply of..... 225
installation of experimental hypochlorite plant at..... 225
Kirkwood, James P., chief engineer original Brooklyn water works..... 49
designer of original water works for Cincinnati..... 49
Lake Charles, La., bursting of frozen services at..... 401
charge for private fire services at..... 412
regulation of private fire services at..... 360
Lake Forest, Ill., charge for reading and maintaining meters owned by consumer at..... 417
charge for reading and maintaining meters owned by water works at.. 418
depth of frost at..... 389
effect of cold weather on water consumption at..... 402
frost below ordinary at..... 390
frozen water mains at..... 390
meters damaged by freezing at..... 407
method of preventing freezing at..... 391

Lake Forest, Ill., responsibility for freezing meters at..... 410
system of setting meters at..... 408
thawing hydrants at..... 397
thawing services at..... 398
Lancaster, Pa., history of water supply of..... 257
low head centrifugal pumps at..... 135
summary of leaks found by survey at..... 260
water consumption at..... 258
Lane, Moses, engineer on original Brooklyn water works..... 48
Laodicea in Phrygia, water supply of..... 1
Laying Water Mains Under Streams, or How We Crossed Two Streams with Ward Pipe at Rome, Georgia. Paper by M. L. Worrell..... 147
Lead, amount corroded by one ampere in one year..... 161
flanged connections, experience with..... 420
lined pipe, use of at Baltimore, Md..... 295
services destroyed by electrolysis..... 296
Leakage survey, method and cost of at Lancaster, Pa..... 257
Leaks, advantage of stopping..... 247
amount of in Chicago..... 247
amount of in Washington, D. C..... 246
amount of water lost by in Washington, D. C..... 253
analysis of underground in Washington, D. C..... 246
best detected by installing meters..... 262
caused by theft..... 247
classification of.....245, 253
classification of at Lancaster, Pa..... 260
classification of in distribution system..... 245
classification of pump..... 245
control of by house to house inspection..... 254
cost of..... 245
cost of prevention in Chicago..... 263
cost of pump, at Chicago..... 245
cost of survey, for at Lancaster, Pa..... 260
discovery of by pitometer survey..... 253
do not always show on surface..... 245
does it pay to stop them..... 245
in 36-inch force main at Lancaster, Pa..... 261
loss of water by in Chicago..... 254
method of survey for at Lancaster, Pa..... 259
not accounted for by elevator indicators..... 319
organization of survey for at Lancaster, Pa..... 258
outfit for survey for at Lancaster, Pa..... 258
reduction of pressure caused by..... 246
water lost by at Lancaster, Pa..... 261
water saved by stopping at Lancaster, Pa..... 261
where they cause expense..... 247
Litterer, Fred, obituary notice..... 426

Little Falls, N. J., hypochlorite sterilization at..... 235
results of hypochlorite treatment at..... 236
Louisville, Ky., earnings of water company..... 337
sprinkling streets by street car companies at.....349, 350
Macallen, insulating joint..... 186
Malleable Iron, used for saddles in construction of continuous wood stave pipe..... 341
Manholes in wood stave pipe at Atlantic City..... 315
Marcia Aqueduct at Rome, B. C., 144–140..... 4
Mark, Dr. E. H., analysis of Owensboro, Ky., water by..... 215
McAdoo tunnel system, motto of..... 82
Mechanical principles of reinforced concrete, discussion on..... 109
Memphis, Tenn., charge for private fire services at..... 368
Meridian, Miss., charge for private fire services..... 366
pipes crossing streams at..... 155
Meter rates at Wilmington, Del..... 264
Meters, better than house to house inspection.....262, 263
charge for reading and maintaining privately owned.....416
damage to by freezing..... 407
fail to stop underground leaks..... 266
opposition to overestimated..... 266
per capita consumption lowered by at East Orange, N. J..... 265
per cent of consumption shown by..... 250
precautions taken to prevent freezing..... 409
on private fire services at Richmond, Va..... 367
rates that allow waste of water..... 264
responsibility for damage by freezing..... 410
system of setting..... 408
Method of Increasing the Depth of Large Wooden Settling Basin. Paper by A. H. Meyers..... 305
Method and Cost of Leakage Survey at Lancaster, Pennsylvania. Paper by F. H. Shaw..... 257
Metropolitan Water District, cold weather water waste in..... 406
Milk, cause of typhoid at Harrisburg, Pa..... 238
Millivoltmeter, description of as used for electrolysis surveys..... 169
Mine Operators, sanitary work by..... 317
Mobile, Ala., bursting of frozen services at..... 401
checking cold weather waste at..... 404
control of private fire service at..... 415
depth of frost at..... 389
effect of cold weather on water consumption at..... 403
frozen water mains at..... 390
injury from breaking private fire services at..... 360
purchase of coal by B.t.u. at..... 351
regulation of private fire services at..... 359
success of municipal ownership at..... 349
system of setting meters at..... 408
thawing services at..... 399

Monessen, Pa., action taken when main frozen at..... 396
bursting of frozen services at..... 401
charge for private fire services at..... 413
charge for reading and maintaining meters owned by water works at 418
control of private fire services at..... 415
effect of cold weather on water consumption at..... 402
depth of frost at..... 389
frost below ordinary at..... 390
frozen water mains at..... 390
meters damaged by freezing at..... 407
method of preventing freezing at..... 391
responsibility for freezing meters at..... 410
thawing services at..... 399
More than Fifty Years Reminiscences in Water Works. Paper by H. G. H. Tarr..... 47
Municipal bookkeeping, items not accounted for in.....331
Municipal ownership, is it a success?..... 349
Municipal water works, rates and bookkeeping methods compared with privately owned..... 335
Municipality, advantage of lower interest rates..... 339
Muskogee, Oklahoma, settling basins at..... 89
water supply of..... 89
New Orleans, La., charge for private fire services at..... 413
depth of frost at..... 389
experience with lead flange connections at..... 421
injury from breaking private fire services at..... 360
regulation of private fire services at..... 360
responsibility for freezing meters at..... 410
system of setting meters at..... 408
waste of water to prevent freezing of hydrants, etc..... 403
New York, Croton water supply charter 1834..... 21
district gauging of water consumption in..... 38
first public water supply 1774..... 21
high pressure fire service system of..... 66
insulated outgoing and return underground conductors in conduits in. 181
Manhattan Water Company 1799..... 21
old water supply of..... 21
organization of bureau of water supply of..... 21
New York Board of Water Supply..... 27
New York Bureau of Water, aim of supply bureau..... 79
adopted organization of..... 68
economy by re-organization of..... 73
force and salary account of..... 71
general organization of..... 61
organization of in 1909..... 66
underlying principles of plan of re-organization of..... 67
work under chief engineer 1902 and 1912..... 72
New York water supply, act authorizing, June 3, 1905..... 27
Newark, N. J., charge for private fire services at..... 361

Newark, N. J., regulation of private fire services at..... 361
Newport, Ky., no charge for private fire services at..... 367
Niagara River, surface ice does not form on account of swift current.... 303
Nismes, ancient aqueduct at..... 16
North Attleboro, Mass., action when mains are frozen at..... 396
bursting of frozen mains at..... 400
bursting of frozen services at..... 401
charge for private fire services at..... 413
charge for reading and maintaining meters owned by consumer at... 417
control of private fire services at..... 416
cold weather waste at..... 404
cold weather waste of metered water at..... 405
depth of frost at..... 389
effect of cold weather on water consumption at..... 402
experience with lead flange connection at..... 421
frost below ordinary at..... 390
frozen water mains at..... 390
injury from breaking of private fire services at..... 360
method of preventing freezing at..... 391
precautions to prevent meters freezing at..... 410
system of setting meters at..... 408
thawing hydrants at..... 397
thawing services at..... 399
waste of water to prevent freezing of hydrants at..... 403
Nuisances, danger of from sewage on small streams..... 282
Obituary..... 425
Ocean, for sewage disposal..... 273
Omaha, hypochlorite treatment at..... 236
Organization of the Bureau of Water Supply, city of New York..... 61
Owensboro, Ky., softening plant put in operation December, 1911..... 204
water softening at..... 203
water supply of..... 203
Oysters, affected by disposal of sewage in bays..... 275
Patria in Syria, aqueduct at..... 2
Pawtucket, R. I., pumping engine at..... 50
Per capita estimate of consumption, inadequacy of..... 35
Phenomenal Growth of the Water Works of Edmonton, Alberta. Paper by A. Maclean..... 289
Philadelphia, centrifugal pumps in Torresdale filter plant..... 133
Philosophy of Purchasing Supplies. Paper by Elihu Cunyngham Church..... 75
Pipe, Brooklyn specifications for..... 50
breaking out defective with dynamite..... 351
crossing stream at Atlantic City..... 316
economical method of laying..... 322
history of manufacture of..... 51
iron, is corroded where electric current leaves it..... 160
repairing Ward joint under stream..... 154
variation in life of cast iron..... 328

Pipe, use of cement in St. Paul..... 55
Use of lead lined at Baltimore, Md..... 295
Pipe crossing stream, at Meridian, Miss..... 156
danger of injury to..... 153
Pipe under streams, use of Knuckle joints on..... 154
Pipe lines, breathing of..... 321
effect of high resistance joints in, on electric currents..... 167
Pipes, electric currents on underground not sufficient to heat..... 159
negative to rails distant from power station..... 170
positive to rails near power station..... 170
protection of gas service, in Baltimore..... 295
Planning and dispatching applied to water department work..... 86
Politics, cause of poor management of sewage plants..... 270
effect of on water works management..... 85
Pollution of streams..... 317
natural, on water sheds..... 279
of bays, from navigation..... 276
Pollution of rivers, apportionment of among towns..... 278
Pollution of streams, effect on water supply..... 278
Pont du Gard aqueduct at Nismes..... 16
Potential difference not conclusive evidence of stray currents..... 170
Potential surveys—how to make..... 169
instruments used for..... 169
plotting on map..... 170
Principles of Efficiency Applied to Water Works. Paper by Harrington Emerson..... 81
Private fire services, approval of chief of fire department for..... 363
charge for..... 361, 364, 387, 411
charge for at Atlanta, Ga..... 366
at East Orange, N. J..... 370
at Memphis, Tenn..... 369
at Meridian, Miss..... 366
at Newport, Ky..... 367
at Rome, Ga..... 366
charge for based on cost of private supply..... 383
charge for based on insurance..... 377
charge for on minimum meter rate basis..... 377
charges based on size of..... 377
charges for on number of sprinkler heads..... 377
consideration of charge for by Wisconsin public service commission. 374
contamination of Rockford, Ill., water supply by..... 380
how controlled..... 415
indicator posts on..... 362
insurance demand for excessive size of..... 365
limit of size of..... 364
limit of size of, at Richmond, Va..... 368
at Terre Haute, Ind..... 388
meters on at Richmond, Va..... 367
no stealing from in Baltimore..... 374

Private fire services, penalties for misuse of at Baltimore..... 373
rates for, fixed by Wisconsin public service commisions..... 364
regulation of..... 359
regulations governing at Baltimore, Md..... 371
size of limited by size of main..... 378
wrongful use of water from..... 384
Proceedings of American Water Works Association, used in court..... 332
Progress in Adoption of National Standard Hose Coupling and Hydrant Fittings for Public Fire Services. Paper by F. M. Griswold..... 141
"Public be Pleased," the motto of the McAdoo tunnel system..... 82
Pump leaks, classification of..... 245
cost of at Chicago..... 245
Pump slippage, determined by pitometer survey..... 253
Pumping engines, advantages of small units..... 127
annual depreciation of..... 119
comparative duties of reciprocating or turbine..... 132
constant load conditions for..... 129
cost of chiefly used type of..... 117
cost of foundations for..... 137
cost of governed by conditions..... 129
fifty years advance in..... 50
cost of foundations for..... 127
mostly built for direct pumping..... 130
piston speed of reciprocating..... 131
tests of steam driven centrifugal..... 133
types chiefly used for water works service..... 117
used mostly on direct pumping systems..... 125
work under varying load conditions..... 135
Pumping engines, paper on, by Charles A. Hague..... 117
Pumping machinery, annual charges against..... 118
improvement in..... 56
Pumping plants, annual charges against boiler plant..... 118
comparative cost of reciprocating and steam turbine driven..... 120
Pumps, durability of centrifugal..... 133
turbine driven centrifugal for water works service..... 117
Pure water, time required to induce use of..... 240
Purification, degree of for sewage..... 269
factor of safety in water..... 281
Purification of water cheaper than of sewage..... 280
Queens County, water supply of..... 26
Question Box..... 349
Question, action to regulate private fire services at time of fires..... 359
Best method aërating well water charged with hydrogen sulphite gas 419
Crippling of service by breaking of private fire service..... 360
Did frozen mains burst from expansion of water in freezing..... 400
Did frozen services burst from expansion of water in freezing..... 400
Do street car companies sprinkle streets..... 349
Experience with lead flange connections..... 420

Question, How are private fire services controlled.. 415
How many meters were lost or damaged by freezing.. 407
How much below ordinary depth did frost penetrate.. 390
Is it practicable to use incinerating plant for steam power pumping. 351
Is municipal ownership a success.. 349
Is the purchase of coal by B.t.u. preferable to purchase by weight. 354
To what depth did frost penetrate during the extreme cold weather of last winter.. 389
To what extent did waste of water occur in metered services.. 405
Was consumer or water works responsible for damage by freezing meters.. 410
Was water wasted to prevent freezing of hydrants.. 403
Were water mains in gridiron system frozen.. 390
What action was taken when hydrants or hydrant laterals were frozen.. 397
What action was taken when mains were frozen.. 396
What action was taken when service pipes were frozen.. 398
What charge is made for private fire service.. 411
What effect did material of service have on action of frost.. 401
What is best way of increasing supply from flowing wells .. 419
What is the system of setting meters.. 407
What means were adopted to check cold weather waste of water.. 403
What means used to prevent freezing of mains, hydrants and services during extreme cold weather.. 391
What special precaution or action was taken to prevent freezing of meters.. 409
What was the effect of cold weather on water consumption.. 401
When meters owned by consumer is rent charged.. 416
When meter owned by water works is charge made for reading and maintaining.. 418
Quincy, Ill, action when mains frozen at.. 397
bursting of frozen services at.. 401
charge for private fire service at.. 413
charge for reading and maintaining meters owned by water works at. 418
control of private fire services at.. 416
experience with lead flanged connections at.. 421
depth of frost at.. 389
effect of cold weather on water consumption at.. 402
effect of freezing on different service materials at.. 401
frost below ordinary at.. 390
frozen water mains at.. 390
injury from breaking of private fire services at.. 360
method of preventing freezing at.. 391
precaution to prevent meters freezing at.. 410
regulation of private fire services at.. 359
responsibility for freezing meters at.. 410
system of setting meters at.. 408
thawing services at.. 399
Radial return feeders for minimizing electrolysis.. 194

Rahway, N. J., action when mains frozen at 397
bursting of fire services at 401
charge for private fire services at 413
charge for reading and maintaining meters owned by consumer at ... 417
charge for reading and maintaining meters owned by water works at 418
control of private fire services at 416
cold weather waste of metered water at 406
depth of frost at 389
effect of cold weather on water consumption at 402
experience with lead flanged connections at 421
frost below ordinary at 390
frozen water mains at 391
injury from breaking of private fire services at 361
meters damaged by freezing at 407
method of preventing freezing at 392
regulation of private fire services at 360
responsibility for freezing meters at 410
system of setting meters at 408
thawing services at 399
Records, reliable immediate and adequate necessary for efficiency 85
standard method for keeping recommended 252
Reinforced concrete, discussion of mechanical principles of 109
specifications for 113
use of deformed bars in 115
use of in hypochlorite plant 226
settling basin, principles of designed of 89
Reliable Presumptive Quantitative Test for B. Coli. Paper by S. T. Powell 307
Reminiscences in water works, more than fifty years of, by H. G. H. Tarr 47
Repairing Ward joint pipe at Wilmington, Del 154
Reservoirs, concrete, watertight joint for 111
on Croton water shed 26
terminals of Roman aqueducts 14
Rhodes, George I., paper on reduction of earth currents by negative feeders 189
Richmond, Ind., charge for private fire service at 413
charge for reading and maintaining meters owned by water works at 418
control of private fire services at 416
checking cold weather waste at 404
depth of frost at 389
effect of cold weather on water consumption at 402
frost below ordinary at 390
frozen water mains at 391
injury from breaking private fire services at 361
meters damaged by freezing at 407
method of preventing freezing at 392
precautions to prevent meters freezing at 410
regulation of private fire services at 360

Richmond, Ind., responsibility for freezing meters at 410
system of setting meters at 408
thawing hydrants at 497
thawing services at 399
waste of water to prevent freezing of hydrants at 403
Richmond, Va., centrifugal pumps used in 137
electrolysis troubles at 299
jurisdiction of superintendent of water works over water shed at 243
limit of size of fire services at 368
meters on private fire services at 367
Richmond County, N. Y., water supply of 26
River pollution, apportionment of among towns 278
Rivers, future control of storm waters entering 281
pollution of by city sewage 278
pollution by private sewers and factory waste 278
should be maintained unpolluted 281
Rivers and small streams for sewage disposal 277
Rock Island, Ill., effect of water purification on typhoid rate at 240
Rockford, Ill., contamination of water supply by fire service at 380
Roman aqueducts, as described by Frontinus 9
Alsietinus, A. D. 10 6
Anio Novus, A. D. 38–52 8
Ano Vetus, B. C. 272–269 4
Appian, B. C. 312 4
Aqua Pia, A. D. 1860–1870 20
Aurelia, A. D., 185 12
Claudia, A. D. 38–52 6
Hadriana, A. D. 109 12
Julia, B. C. 33 6
Marcia, B. C. 144–140 4
Tepula, B. C. 144–140 6
Trajana, A. D. 109 9
Virgo, B. C. 19 6
at Nismes 16
at Segovia, Spain 16
at Constantinople 20
Romans, builders of greatest ancient water works 2
Rome, ancient, domestic water supply of 14
distribution of water in 16
level used in ancient 12
modern water supply of 20
private water company at 20
water consumption at 14
water works of ancient 4
Rome, Ga., charge for private fire services at 366
water main under streams at 147
Salt, to prevent freezing of hydrants 393
San Antonio, Tex., water used for manufacturing purposes at 251
Sanitary work, by mine operators 317

Sault Ste. Marie, Ontario, action when mains frozen at ... 397
checking cold weather waste at ... 404
charge for private fire services at ... 413
control of private fire services at ... 416
depth of frost at ... 389
experience with lead flanged connections at ... 421
frost below ordinary at ... 390
frozen water mains at ... 391
method of preventing freezing at ... 392
precautions to prevent meter freezing at ... 410
regulation of private fire services at ... 360
responsibility for freezing meters at ... 411
system of setting meters at ... 409
thawing hydrants at ... 498
thawing services at ... 400
Segovia, Spain, ancient aqueduct at ... 16
Service pipes, protection of by gas company in Baltimore ... 295
Services, regulation of private fire ... 359
size of determined on floor area basis ... 42
wisdom of using galvanized iron in paved streets ... 293
Settling basins, action of forces on reinforced concrete ... 101
advantages of continuous ... 90
causes of leakage in ... 94
cement wash for reinforced concrete ... 108
connection of walls and bottom in reinforced concrete ... 101
corner design for reinforced concrete ... 106
cost of reinforced concrete ... 108
cost of underdrain system of ... 92
counterforts vs. buttresses in construction of reinforced concrete ... 95
description of at Muskogee, Oklahoma ... 89
design of counterforts in reinforced concrete ... 103
design of side walls of reinforced concrete ... 98
design of underdrains for ... 91
details of design of reinforced concrete ... 96
discussion of reinforced concrete ... 93
estimate of material and cost of reinforced concrete ... 108
footing design of reinforced concrete ... 106
horizontal joints used freely in reinforced concrete ... 108
importance of structural details of reinforced concrete ... 95
operation of continuous ... 91
principles of reinforced concrete ... 89
quantity of water used for cleaning continuous ... 93
removal of sludge from continuous ... 90
specifications for reinforced concrete ... 113
system of sludge removal from ... 92
value of continuous ... 89
vertical joints avoided in reinforced concrete ... 108
waterproofing not necessary for reinforced concrete ... 94
water tightness of reinforced concrete ... 94

Sewage, consideration of bathing privileges in discharge of into ocean.. 283
consideration of size of river discharged into..... 283
considerations when discharging into bays..... 282
discharge of into bays..... 282
disposal of considered according to classification..... 272
disposal of in bays and sounds..... 275
disposal plants do not always give required results..... 269
disposal plants must be complete when discharging into small streams and lakes..... 283
electrical disinfection of..... 282
purification of as factor of safety in filtration of water.....281, 284
purification of, to take burden off water supply misleading..... 285
question of discharge into ocean..... 282
raw should not be discharged into rivers used for water supply..... 283
rivers and small streams for disposal of..... 277
to what degree must it be purified..... 269
Sewage discharge into rivers, interest of cities down stream..... 285
Sewage disposal, any degree of purification possible in..... 272
a cause of uneconomical methods of..... 271
consideration of general public welfare in..... 271
correlated with water supplies..... 286
difficulty of adjusting rights of oyster growers..... 275
effect of on oyster culture..... 276
effect of surf bathing on requirements of..... 274
how approached by state boards of health..... 284
in oceans, aspects of, requiring careful consideration..... 274
low cost of avoiding nuisances by discharge into ocean..... 272
must be viewed from standpoint of liability of infection..... 273
ocean for..... 273
rudimental when discharged into ocean..... 273
Sewage disposal plants, economical design of..... 271
effluent of purer than conditions warrant..... 269
importance of employing specialists in design of..... 271
inefficient management of..... 270
not being operated for bacterial results..... 285
Sewage purification, bacterial standard now demanded for..... 272
expense of, to render effluent potable, prohibitive..... 286
financial limit of cities to carry out..... 285
inconsistencies in requirements for..... 270
what it might require..... 287
Sludge, system of removal of..... 92
removal of from continuous settling basins..... 90
Smith, J. Waldo, chief engineer, New York board of water supply..... 27
Soil, alkaline conducive to electrolysis..... 297
conductivity of as compared with iron..... 164
does not conduct metallically..... 160
electrical resistance of..... 164
when dry does not conduct electric currents..... 160
Specifications for reinforced concrete settling basins..... 113

Spokane, Wash., action when mains frozen at 397
charge for private fire services at 413
charge for reading and maintaining meters owned by consumer at 417
control of private fire service at 416
depth of frost at 389
effect of cold weather on water consumption at 403
experience with lead flanged connections at 421
frozen water mains at 391
injury from breaking of private fire services at 361
meters damaged by freezing at 407
method of preventing freezing at 392
precaution to prevent meter freezing at 410
regulation of private fire services at 359
responsibility for freezing meters at 411
system of setting meters at 409
thawing hydrants at 398
thawing services at 400
waste of water to prevent freezing of drinking fountains at 403
Springfield, Mass., adoption of standard hose coupling by 142
Sprinkling streets by car companies 349
St. Louis, Mo., adoption of standard hose coupling by 142
Standardized operations 88
Standards, necessity of for efficiency 86
Steam driven centrifugal pumps, work under varying loads 135
Steam turbine, development of 119
Steam turbine driven centrifugal pumps, durability of 133
require gear drive 130
Steam turbines, maintaining vacuum with 138
Steel, why not used for wood stave pipe bands at Atlantic City 314
Steel pipe at Atlantic City 313
Sterilization, compressed liquid chlorine for 220
Sterilization, temporary plant for at Kansas City, Mo 225
Sterilization by hypochlorite at Kansas City, Mo 225
Stratford, Ontario, bursting of frozen mains at 400
bursting of frozen services at 401
charge for private fire services at 414
charge for reading and maintaining meters owned by consumer at 417
control of private fire services at 416
depth of frost at 389
effect of cold weather on water consumption at 403
effect on freezing of services of various materials at 401
frost below ordinary at 390
frozen water mains at 391
injury from breaking of private fire services at 361
methods of preventing freezing at 392
Meters damaged by freezing at 407
precautions to prevent meter freezing at 410
regulation of private fire services at 359
responsibility for freezing meters at 411

Stratford, Ontario, system of setting meters at 409
thawing hydrants at 398
thawing services at 400
Stray currents, a fire hazard 179
not a loss to railway company 166
potential difference not conclusive evidence of 170
sources of 161
Stream, crossing of with 48-inch force main at Atlantic City 316
Streator, Ill., charge for private fire services at 414
charge for reading and maintaining meters owned by consumer at ... 417
charge for reading and maintaining meters owned by water works at 419
cold weather waste of metered water at 406
control of private fire services at 416
depth of frost at 389
effect of cold weather on water consumption at 403
frost below ordinary at 390
frozen water mains at 391
injuries from breaking private fire services at 361
meters damaged by freezing at 417
method of preventing freezing at 392
precautions to prevent meter freezing at 410
regulation of private fire services at 359
responsibility for freezing meters at 411
system of setting meters at 409
Suffern, N. Y., action when mains frozen at 397
bursting of frozen mains at 400
bursting of frozen services at 401
depth of frost at 389
effect of cold weather on water consumption at 403
frost below ordinary at 390
frozen water mains at 391
meters damaged by freezing at 407
method of preventing freezing at 392
thawing services at 401
responsibility for freezing meters at 411
system of setting meters at 409
Supplies, philosophy of purchase of 75
Sulphuric acid, in streams passing McKeesport, Pa 317
Surveys for electrolysis 169
Table for computation of currents on pipes 197
Tampa, Fla., charge for reading and maintaining meters owned by consumer at 417
experience with lead flanged connections at 431
regulation of private fire services at 359
system of setting meters at 409
Temperature, effect on chlorination 221
Terre Haute, Ind., limit of size of private fire services at 388
Thompson, Hon. Henry S., Water Commissioner, New York City 67
To What Degree Must Sewage be Purified. Paper by Chester G. Wigley 269

Toledo, Ohio, action when mains frozen at..... 397
charge for reading and maintaining meters owned by consumer at... 417
charge for reading and maintaining meters owned by water works at 418
control of private fire service at..... 416
depth of frost at..... 389
effect of cold weather on water consumption at.....403
frost below ordinary at..... 390
frozen water mains at..... 391
injury from breaking private fire services at..... 361
meters damaged by freezing at..... 407
method of preventing freezing at..... 392
regulation of private fire services at..... 359
responsibility of freezing meters at..... 411
system of setting meters at..... 409
thawing hydrants at..... 398
thawing services at..... 400
Tunnelling by "fire setting" for Roman aqueducts..... 14
Turbine Driven Centrifugal Pumps for Water Works Service.
Paper by W. O. Beyer..... 117
Typhoid by fly infection..... 222
due to milk at Harrisburg, Pa..... 238
effect of filtration on seasonal distribution of..... 223
effect of filtration on, at Harrisburg, Pa..... 238
at Wilmington, Del..... 241
effect of hypochlorite sterilization on rate at Kansas City..... 231
fall rise due to general sanitation..... 225
fall rise marked in cities having filtered water..... 239
highest at Wilmington, Del., in fall when water was best..... 241
more from lack of sanitation than water supply..... 238
per cent due to water supply and to sanitation..... 237
responsibility of health departments in finding distribution of cases.. 242
rate does not follow condition of water..... 241
rate of in cities having filtered water..... 239
rates at Atlanta, Ga., and Birmingham, Ala..... 238
reduction in by filtration at Rock Island, Ill..... 240
reduction in rate by installation of filters..... 239
seasonal distribution of..... 222
seasonal fluctuation due to water in spring and sanitation in fall.....240
Vacuum, ease of obtaining high in water works practice..... 136
Value of a Continuous Settling Basin and a Discussion of the Economic Principle of Design of Such Reinforced Concrete Structures. Paper by Alexander Potter..... 89
Vitruvius, description of ancient level by..... 12
Voltage, amount required to produce electrolysis..... 161
Walkerville, Ontario, bursting of frozen services at..... 401
charge for private fire services at..... 414
precaution to prevent meters freezing at..... 410
charge for reading and maintaining meters owned by consumer at... 417
depth of frost at..... 389

Walkerville, Ontario, frost below ordinary at..... 390
frozen water mains at..... 391
method of preventing freezing at..... 329
system of setting meters at..... 409
thawing hydrants at..... 398
Ward pipes under streams at Rome, Ga..... 147
Washington, D. C., analysis of underground leaks in..... 246
double overhead trolley at..... 181
loss by leakage in..... 246
proportion of water waste in..... 253
Waste, adjustment of meter rate to avoid..... 264
Water, cost of saving in Chicago..... 263
factor of safety in purification of..... 284
filtration of not always reliable..... 280
importance of conservation of..... 263
made conducting by addition of salt..... 159
pure non-conductor..... 159
"pure and potable" literally construed by courts..... 272
salts in, act as electrical conductor..... 159
storm as bad as sewage from bacterial standpoint..... 279
storm has not caused disastrous results..... 279
that of state should be available for water supply in unpolluted condition..... 281
Water companies, rates and bookkeeping methods compared with municipal plants..... 325
Water consumption, analysis of in Chicago..... 254
as shown by meter readings..... 249
at East Orange, N. J..... 256
at Lancaster, Pa..... 258
cold weather increase of metered water..... 405
district gaugings of in New York..... 88
domestic in American cities..... 249
effect of cold on..... 406
effect of cold weather on..... 402
estimated consumption per 1000 square feet in New York..... 40
floor area unit as basis for estimating..... 35
for business uses..... 250
for manufacturing..... 251
in British cities..... 248
in Chicago..... 254
in 166 American cities..... 247
need of segregation of uses of..... 249
per capita usual estimate of..... 35
per cent shown by meters in fully metered cities..... 250
variation in per capita in New York..... 39
Water department, benefit of efficiency rewards in..... 85
reliable, immediate and adequate records necessary in..... 85
value of standards to..... 87
Water department supplies, advantage of buying large quantities..... 78
bids for different classifications..... 78

Water department supplies, consumable and non-consumable compared.. 76
contracts for should be awarded promptly..... 79
effect of competition on prices..... 78
effect of definite specifications on prices..... 77
emergency..... 78
getting the right material..... 75
how to obtain low prices for..... 78
impracticability of trying before paying for..... 77
necessity of business methods in purchase of..... 79
philosophy of purchasing..... 75
preventing accumulation of old material..... 76
price effected by definite specifications for..... 77
principles governing the purchase of..... 75
prompt payment for by systematic methods..... 79
reduction in delivery charges by large purchases of..... 79
requisitions for..... 75
storage and care of..... 76
specifications for..... 76
specifications for should be definite..... 77
specifications vs. calling for results..... 77
value of placing small orders for some..... 78
Water mains under streams..... 147
Water pipes, as electric conductor..... 164
effect of stray electric currents on..... 166
Water purification, factor of safety in..... 281
results of not always immediate..... 240
to take care of sewage pollution..... 280
use of compressed liquid chlorine for..... 220
Water rates, comparison of municipal and private company..... 331
flat unfair..... 338
Water Softening at Owensboro, Kentucky. Paper by E. H. Breidenbach..... 203
Water softening at Owensboro, Ky., bacterial reduction by..... 215
chemicals used in..... 207
cost of plant for..... 216
cost per million gallons of..... 216
description of plant for..... 204
labor required for..... 204
materials used in..... 208
preparation of chemicals for..... 207
purification effected by..... 215
results of..... 208
Water supply, benefits of abundance of..... 82
competent counsel should be sought in selection of source of..... 84
conservations of by sewage purification..... 279
discipline in administration in..... 84
economy in..... 83
effect of politics in management..... 85
ideals of..... 82
use of "common sense" in..... 83

Water supply, waste of 83
of boroughs of Greater New York 61
of Buffalo, N. Y. 301
Water waste survey, cost of at Lancaster, Pa 260
method of at Lancaster, Pa 259
outfit for at Lancaster, Pa 258
organization of at Lancaster, Pa 258
Water works, ancient and modern, Wegman 1
antiquity of 47
cost of tactless management of 53
description of at Edmonton, Alberta 290
importance of 47
in Asia Minor 1
in Egypt 1
of Jerusalem 1
of Laodicea, Phyrgia 1
phenomenal growth of at Edmonton, Alberta 289
Water works bonds, sale of in early days 52
Water works franchises in early days 53
Water works ideals, abundance, continuity of service, comfort and economy 82
safe the main 82
Water works management, fifty years development in 55
tact in 53
Waterloo, Iowa, charge for private sprinkler service at 379
Waterproof, joints in concrete dam 111
Waterproofing, effect on concrete 110
Waterproofing compounds, effect on concrete 110
Wells, method of increasing supply from flowing 419
Weston millivoltmeter, for electrolysis survey 169
Whitney, E. S., resident engineer Muskogee settling basin 109
Wisler, J. M., obituary notice 427
Wood pipe, types of 314
why spiral wound, factory made not used at Atlantic City 314
Wood stave force main at Atlantic City 313
Wood stave pipe, coating of bands for at Atlantic City 314
cost of 48-inch continuous 316
crossing streams with 315
flange joints in 315
how built at Atlantic City 315
joining to a cast iron pipe 315
manholes on 315
method of crossing stream on line of 316
round iron used for banding 314
upsetting thread ends of bands for 314
weight of 48-inch main full, compared with cast iron 316
wood selected for at Atlantic City 315
Wooden settling tank, method of increasing depth of 305
Wrought iron, use of for wood stave pipe band 314
Youghiogheny River, amount of sulphuric acid carried by 317

AUTHORS INDEX

Abbott, C. E. Experience with economical pipe laying..... 322
Ackerman, Walter. Discussion on depreciation.....329, 330, 332
Affleck, John A. Discussion on experience with private fire services..... 367
Alvord, John W. Discussion on depreciation.....325, 329, 330, 333, 334
Discussion on renewal charges..... 334
Baker, M. N. Discussion on health statistics..... 242
Discussion on power from incinerating plants..... 353
Discussion on sewage purification..... 284
Barnett, J. Davis. Discussion on depreciation..... 338
Bartow, Dr. Edward. Discussion on hypochlorite sterilization..... 240
Bauer, Leonard. Discussion on experience with lead flanged connections 423
Discussion on experience with private fire services..... 367
Discussion on experience with hydraulic elevators..... 318
Berry J. P. Discussion on experience with private fire services..... 379
Discussion on steam turbine and centrifugal pumps..... 139
Beyer W. O., Paper by, Turbine Driven Centrifugal Pumps for Water Service..... 117
Breidenbach, E. H., Paper by, Water Softening at Owensboro, Kentucky..... 203
Discussion on electrolysis from railway currents..... 199
Discussion on electrolysis of service pipes..... 296
Discussion on freezing of hydrants..... 395
Brush, William W., Paper by, Floor Area Unit as a Basis for Estimating Consumption..... 35
Discussion on Floor area consumption.....42, 43, 44, 45, 46
Butler, J. S. Discussion on hypochlorite sterilization..... 232
Caulfield, John. Discussion on water works reminiscences..... 55
Experience with elevator indicators..... 320
Chester, J. N. Discussion on cost of waste.....251, 252
Discussion on depreciation.....327, 329, 330, 331, 338
Discussion on municipal accounting..... 339
Discussion on municipal bookkeeping..... 331
Discussion on private fire services..... 362
Discussion on steam turbine and centrifugal pumps 124, 138, 139
Church, Elihu Cunyngham., Paper by, The Philosophy of Purchasing Supplies..... 75
Discussion on purchase of supplies..... 80
Clement, R. L. Discussion on experience with private fire services....371, 376
Discussion on proper size of fire hydrant..... 324
Discussion on service pipes..... 295
Discussion on experience with elevators..... 319

Cole, Edward S., Paper by, The Cost of Leaks; Does it Pay to Stop Them.... 245
Discussion on cost of waste.... 253
Discussion on floor area consumption.... 43, 45
Discussion on locating, measuring and repairing leaks.... 262
Discussion on steam turbines and centrifugal pumps.... 133
Connor F. J. Discussion on electrolysis of service pipes.... 297
Discussion on freezing of hydrants.... 394
Discussion on growth of Edmonton water works.... 293
Discussion on service pipes.... 294
Cramer, W. S. Discussion on depreciation.... 329
Crane, Guy G. Discussion on experience with private fire services.... 380
Davis, E. E. Discussion on electrolysis of service pipe.... 299, 300
Discussion on experience with lead flanged connections.... 423
Discussion on experience with private fire services.... 367, 376
Discussion on powers and work of health departments.... 243
Discussion on steam turbine and centrifugal pumps.... 137
Discussion on experience with elevator indicators.... 320
De Berard, W. W. Discussion on hypochlorite sterilization.... 242
De Varona, I. M., Paper by, Organization of the Bureau of Water Supply, City of New York.... 61
Diven, J. M. Discussion on cold weather waste of water.... 406
Discussion on freezing of hydrants.... 293
Discussion on growth of Edmonton water works.... 292
Discussion on water works reminiscences.... 60
Dunham, H. F. Discussion on steam turbines and centrifugal pumps.... 135
Emerson, Harrington, Paper by, The Principles of Efficiency Applied to Water Works.... 81
Discussion on purchase of supplies.... 80
Fewell, J. H., Discussion on service pipes.... 296
Folwell, A. Prescott. Discussion on hypochlorite sterilization.... 237
Foster, Ernest H. Discussion on power from incinerating plants.... 357
Fulton, J. S. Discussion on steam turbines and centrifugal pumps.... 134
Ganz, Albert F., Paper by, Electrolysis from Stray Electric Currents.... 159
Discussion on electrolysis from railway currents.... 198, 199, 201
Griswold, F. M., Paper by, Progress in the Adoption of the National Standard Hose Coupling and Hydrant Fittings for Public Fire Service.... 141
Gwinn, Dow R. Discussion on continuous settling basins.... 112
Discussion on depreciation.... 344
Discussion on experience with private fire services.... 381, 387
Discussion on experience with lead flanged connections.... 422
Discussion on electrolysis of service pipes.... 296
Discussion on growth of Edmonton water works.... 292
Discussion on hypochlorite sterilization.... 232, 242
Discussion on locating, measuring and repairing leaks.... 262, 267
Discussion on power from incinerating plant.... 357
Discussion on sewage purification.... 283
Discussion on experience with elevator indicators.... 319

High, S. Y., Paper by, Hypochlorite Sterilization at Kansas City, Missouri ... 225
Hooker, William. Discussion on power from incinerating plants ... 354
Houston, George. Discussion on experience with private fire services. 381, 387
Jackson, D. D., Paper by, Chlorination Plant at Cleveland, Ohio ... 219
Discussion on hypochlorite sterilization ... 237, 238, 239
Kay, Prof. Edgar B. Discussion on mechanical principles of reinforced concrete ... 115
Keeler, H. E. Discussion on water works accounting ... 340
Kennedy, George G. Discussion on hypochlorite sterilization ... 232, 238
Discussion on locating, measuring and repairing leaks ... 264
Kienle, John A. Discussion on hypochlorite sterilization ... 241
Discussion on locating, measuring and repairing leaks ... 263, 266
Discussion on pipes under streams ... 153
Leal, Dr. J. L. Discussion on hypochlorite sterilization ... 233
Leisen, Theodore A. Discussion on depreciation ... 336
Discussion on municipal bookkeeping ... 335
Discussion on power from incinerating plants ... 351, 355
Discussion on sprinkling streets by street car companies ... 349
Discussion on steam turbines and centrifugal pumps ... 124
Leopold, F. B. Discussion on hypochlorite sterilization ... 238
Discussion on sewage purification ... 284
Little, Beekman C. Discussion on sprinkling streets by street car companies ... 350
Luscombe, William. Discussion on cost of leaks ... 253
Discussion on freezing of hydrants ... 394
Lyon, Henry L., Paper by, Ice Troubles at Buffalo ... 301
Discussion on sprinkling streets by street car companies ... 350
Discussion on stream turbines and centrifugal pumps ... 133
Machen, Henry B. Discussion on organization of New York water supply ... 74
Maclean, A., Paper by, Phenomenal Growth of the Water Works of Edmonton, Alberta ... 289
Discussion on electrolysis of service pipes ... 300
Discussion on freezing of mains, hydrants and services ... 393
Discussion on growth of Edmonton water works ... 292, 293
Discussion of ice troubles ... 303
Discussion on service pipes ... 294, 296
McNamee, T. W. Discussion on experience with private fire services ... 377
Meyers, A. H., Paper by, A Method of Increasing the Depth of a Large Wooden Settling Tank ... 305
Miller, Walter E. Discussion on experience with private fire services ... 374
Montfort, W. F. Discussion on electrolysis on service pipes ... 297, 298
Morgan, H. B. Discussion on depreciation ... 328
Discussion on depreciation and accounting ... 337, 345
Phillips, T. C. Discussion on cost of waste ... 253
Discussion on floor area consumption ... 42, 45, 46
Discussion on freezing hydrants ... 395

Potter, Alexander., Paper by, The Value of a Continuous Settling Basin and a Discussion of the Economic Principles of Design of Such Reinforced Concrete Structures 89
Discussion on continuous settling basin 112, 113, 115
Discussion on cost of waste 251
Discussion on depreciation 346
Discussion on experience with private fire services 369
Discussion on floor area consumption 43
Discussion on power from incinerating plant 355
Discussion on sewage purification 285
Discussion on sprinkling streets by street car companies 350
Discussion on steam turbines and centrifugal pumps 138
Discussion on water rates 341
Powell, Shepperd T., Paper by, A Reliable, Presumptive, Quantitative Test for B. Coli 307
Powell, T. J. Discussion on depreciation and water rates 342
Reimer A. A. Discussion on cost of waste 252, 254
Discussion on electrolysis from railway currents 199
Discussion on experiences with private fire services 370
Discussion on growth of Edmonton water works 292
Discussion on locating, measuring and repairing leaks 265
Discussion on size of fire hydrants 324
Rinker, Andrew. Discussion on power from incinerating plants 353
Rosamond, S. J. Discussion on experiences with private fire services 387
Salmon, C. B. Discussion on continuous settling basins 112
Discussion on experiences with private fire services 377
Discussion on return for hydrant service 138
Discussion on steam turbines and centrifugal pumps 138
Schwanhauser, William. Discussion on water works reminiscences 59
Shaw, F. H., Paper by, Methods and Cost of a Leakage Survey at Lancaster, Pennyslvania 257
Discussion on power from incinerating plants 356
Discussion on cost of waste 253
Discussion on experience with private fire services 365
Discussion on locating, measuring and repairing leaks 262, 266, 267
Discussion on mechanical principles of reinforced concrete 115
Discussion on size of fire hydrants 324
Discussion on experience with elevator indicators 319
Sherrerd, Morris R. Discussion on experience with private fire services 361
Discussion on regulation of private fire services 361
Smith, Leslie C. Discussion on depreciation 328, 333, 334
Smith, W. Z. Discussion on experience with private fire services 366, 376
Discussion on power from incinerating plant 352
Stover, F. H. Discussion on hypochlorite sterilization 239
Strothman, L. E. Discussion on steam turbines and centrifugal pumps 128, 136
Tarr, H. G. H., Paper by, More Than Fifty Years Reminiscences in Water Works 47
Discussion on water works reminiscences 60
Thomas, R. J. Discussion on locating, measuring and repairing leaks 262, 266

Thompson, V. A. Discussion on electrolysis of service pipes.....296, 297, 298
Discussion on growth of Edmonton water works.....292, 293
Discussion on municipal accounting and depreciation..... 340
Discussion on service pipes..... 294
Van Gilder, L., Paper by, FORTY-EIGHT INCH WOOD STAVE FORCE MAIN BUILT FOR THE WATER DEPARTMENT OF ATLANTIC CITY.....313
Wegman, Edward., Paper by, ANCIENT AND MODERN WATER WORKS..... 1
Discussion on electrolysis from railway currents..... 198
Discussion on reinforced concrete settling basins..... 109
Wigley, Chester G., Paper by, TO WHAT DEGREE MUST SEWAGE BE PURIFIED..... 269
Discussion on sewage purification..... 283
Wilcox, W. F. Discussion on experience with lead flanged connections.. 422
Discussion on depreciation..... 345
Discussion on hypochlorite sterilization..... 240
Discussion on mechanical principles of reinforced concrete..... 111
Discussion on service pipes..... 295
Discussion on stream pollution..... 317
Discussion on steam turbines and centrifugal pumps..... 138
Experience with air chambers on pipe line..... 321
Experience with breaking out large pipes with dynamite..... 321
Wiles, C. W. Discussion on experiences with private fire services..... 377
Wills, Wirt J. Discussion on experience with private fire services.365, 368, 386
Wood, Stuart. Discussion on municipal accounting..... 332
Discussion on water works reminiscences..... 56
Worrell, M. L., Paper by, LAYING WATER MAINS UNDER STREAMS, OR HOW WE CROSSED TWO STREAMS WITH WARD PIPE AT ROME, GEORGIA..... 147
Discussion on experience with lead flanged connections..... 423
Discussion on experience with private fire services..... 366
Discussion on crossing streams with Ward pipe.....153, 155
Discussion on experience with elevator indicators..... 318
Young, William R. Discussion on experiences with private fire services. 362
Discussion on freezing of mains, hydrants and services..... 393
Discussion on proper size of fire hydrants..... 322
Discussion on experience with elevator indicators..... 319

INDEX TO ADVERTISERS

Alvord & Burdick 40–a
American Asphaltum & Rubber Co 44–a; 45–a
American Car & Foundry Co 46–a
American Cast Iron Pipe & Foundry Co 52–a
American City 3–a
American Pipe & Construction Co 27–a
American Society of Mechanical Engineers 2–a

Bourbon Copper & Brass Works 42–a
Buffalo Meter Co 16–a
Builders Iron Foundry Co 15–a
Bull & Roberts 40–a

Caird, J. M 40–a
Canadian Engineer 4–a
Cassier's Magazine 5–a
Chapman Valve Mfg. Co 53–a
Clark, Wm. G 40–a
Clark Co. H. W 25–a
Coldwell-Wilcox Co 46–a
Colorado Fuel & Iron Co 50–a
Conard, Wm. R 40–a
Cook, A. D 37–a

Dravo-Doyle Co 38–a

Eastern Mfg. Co 53–a
Engineering Magazine 6–a
Engineering News 7–a
Engineering Record 8–a

Farnan Brass Works 29–a
Fire & Water Engineering 9–a
Foster & Hosler 32–a
Fuller, Geo. W 41–a

Gamon Meter Co 18–a
General Chemical Co 35–a
General Electric Co 14–a
Glauber Brass Mfg. Co 30–a

Harrison Bros. & Co 34–a
Hersey Mfg. Co 19–a

Hill Publishing Co. 10–a
Hill Pump Valve Co. 40–a

Illinois Malleable Iron Co. 37–a

Jarecki Chemical Co. 36–a

Kellogg & Co. E. H. 1–a
Kennedy Valve Mfg. Co. 49–a

Ludlow Valve Co. 47–a

Maury, Dabney H. 41–a
Millar & Sons Co. Charles 52–a
Mueller Mfg. Co. H. 31–a
Municipal Journal 11–a

National Meter Co. 20–a
National Water Main Cleaning Co. 28–a
Neptune Meter Co. 21–a
New York Continental Jewell Filtration Co. 33–a

Pennsylvania Salt Mfg. Co. 36–a
Pitometer Co. 17–a
Pittsburgh Filter Co. 39–a
Pittsburgh Meter Co. 22–a
Potter, Alexander 41–a
Potts, Clyde 41–a
Public Service 12–a
Ross Valve Co. 46–a

Smith Mfg. Co. 39–a
Standard Asphalt & Rubber Co. 26–a
Standard Wood Pipe Co. 53–a

Taylor, Samuel A. 41–a
Taylor Co. W. P. 28–a
Thomson Meter Co. 23–a

Union Water Meter Co. 17–a
United States Cast Iron Pipe & Foundry Co. 51–a

Valvoline Oil Co. 38–a

Water & Gas Review 13–a
Weston E. B. 41–a
Weston Robert Spurr 42–a
Wood & Co. R. D. 48–a
Worthington, Henry R. 24–a

Yearance, W. B. 42–a

CLASSIFIED INDEX TO ADVERTISEMENTS

ASPHALT PIPE COATING

American Asphaltum & Rubber Co..... 44–a,45–a
Standard Asphalt and Rubber Co..... 26–a

BRASS FITTINGS

Farnan Brass Works..... 29–a
Glauber Brass Mfg. Co..... 30–a
Mueller Mfg. Co. H..... 31–a

CHEMISTS AND BACTERIOLOGISTS

Bull & Roberts..... 40–a
Caird, James M..... 40–a

CURB COCKS

Farnan Brass Works..... 29–a
Glauber Brass Mfg. Co..... 30–a
Mueller Mfg. Co. H..... 30–a

ENGINEERS—CONTRACTING AND CONSULTING

Alvord & Burdick..... 40–a
American Pipe & Construction Co..... 27–a
Clark, William G..... 40–a
Conard, William R..... 40–a
Fuller, George W..... 41–a
Maury, Dabney H..... 41–a
Potter, Alexander..... 41–a
Potts, Clyde..... 41–a
Taylor, Samuel A..... 41–a
Weston, Edmund B..... 41–a
Weston, Robert Spurr..... 42–a
Yereance, W. B..... 42–a

FILTERS AND FILTER SUPPLIES

General Chemical Co..... 35–a
Harrison Brothers & Co..... 34–a
Jarecki Chemical Co..... 36–a
New York Continental Jewell Filtration Co..... 33–a
Pennsylvania Salt Manufacturing Co..... 36–a
Pittsburgh Filter Manufacturing Co..... 39–a

HOISTING MECHANISM

Coldwell-Wilcox Co..... 46–a

HYDRANTS

Bourbon Copper & Brass Works..... 42–a
Ludlow Valve Manufacturing Co..... 47–a
Ross Valve Co..... 46–a
Wood & Co. R. D..... 48–a

METERS AND METER BOXES

Buffalo Meter Co..... 16–a
Builders Iron Foundry Co..... 15–a
Clark Co., H. W..... 25–a
Gamon Meter Co..... 18–a
General Electric Co..... 14–a
Hersey Manufacturing Co..... 19–a
National Meter Co..... 20–a
Neptune Meter Co..... 21–a
Pitometer Co..... 17–a
Pittsburgh Meter Co..... 22–a
Thomson Meter Co..... 23–a
Union Water Meter Co..... 17–a
Worthington, Henry R..... 24–a

OILS AND LUBRICANTS

Kellogg & Co., E. H..... 1–a
Valvoline Oil Co..... 38–a

PERIODICALS

American City..... 3–a
American Society of Mechanical Engineers..... 2–a
Canadian Engineer..... 4–a
Cassier's Magazine..... 5–a
Engineering Magazine..... 6–a
Engineering News..... 7–a
Engineering Record..... 8–a
Fire & Water Engineering..... 9–a
Hill Publishing Co..... 10–a
Municipal Journal..... 11–a
Public Service..... 12–a
Water & Gas Review..... 13–a

PIPE AND SPECIALS

American Car & Foundry Co..... 46–a
American Cast Iron Pipe Co..... 52–a
American Pipe & Construction Co..... 27–a
Colorado Fuel & Iron Co..... 50–a
Eastern Manufacturing Co..... 53–a
Illinois Malleable Iron Co..... 37–a
Millar & Son Co., Charles,..... 52–a
Standard Wood Pipe Co..... 53–a
United States Cast Iron Pipe & Foundry Co..... 51–a
Wood & Co. R. D..... 48–a

PIPE COATING

Standard Asphalt & Rubber Co. 26–a
American Asphaltum and Rubber Co. 44–a; 45–a

PIPE CLEANING

National Water Main Cleaning Co. 28–a

PNEUMATIC PLANTS

Foster & Hosler 32–a

PUMPS

Cook, A. D. 37–a
Dravo-Doyle Co. 38–a
Wood & Co., R. D. 48–a

SLUICE GATES

Coldwell-Wilcox Co. 46–a
Ludlow Valve Mfg. Co. 47–a

STRAINERS

Cook, A. D. 37–a

TAPPING MACHINES

Mueller Manufacturing Co., H. 31–a
Smith Manufacturing Co., A. P. 39–a

VALVES AND VALVE BOXES

Bourbon Copper & Brass Works 42–a
Chapman Valve Manufacturing Co. 53–a
Hill Pump Valve 40–a
Illinois Malleable Iron Co. 37–a
Kennedy Valve Manufacturing Co. 49–a
Ludlow Valve Manufacturing Co. 47–a
Ross Valve Co. 46–a
Taylor Co., W. P. 28–a
Wood & Co., R. D. 48–a

ADVERTISEMENTS

THE USE OF

INSURES A LARGE

SAVING IN QUANTITY
SAVING IN LABOR
SAVING IN BOILER TROUBLES
SAVING IN POWER
SAVING IN PISTON PACKING
SAVING IN FUEL
SAVING IN WEAR AND TEAR

ECONOMY GUARANTEED

We will send you a sufficient quantity, be it one or more barrels, for a thorough practical test on one or all of your engines for at least 90 days, and, if you do not find ECONOMY and other benefits through its use, we agree to accept settlement on *your* basis of value as compared with the oil you are now using.

THINK IT OVER

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Annual Meeting will be held at the Engineering Building, 29 West 39th Street, New York City, December 3–6, 1912

New York Monthly meetings at the Engineering Societies' Building the second Tuesday of the month from October to May inclusive. Local meetings also held in Boston, St. Louis, San Francisco, Philadelphia, New Haven, Cincinnati

Announcements of meetings will be mailed to those interested, upon request

THE ENGINEERING SOCIETIES' BUILDING

29 WEST 39TH STREET, NEW YORK CITY

Some Leading Manufacturers

in the water works field who make use of **THE AMERICAN CITY** as an advertising medium.

Goulds Manufacturing Co., Seneca Falls, N. Y.
Thomson Meter Co., Brooklyn, N. Y.
Neptune Meter Co., New York, N. Y.
Otto Gas Engine Works, Philadelphia, Pa.
Standard Water Meter Company. Brooklyn, N. Y.
Simplex Valve & Meter Co., Philadelphia, Pa.
The Pitometer Co., New York, N. Y.
Union Water Meter Co., Worcester, Mass.
Buffalo Meter Co., Buffalo, N. Y.
H. W. Clark Co., Mattoon, Ill.
United Seal Co., Columbus, Ohio.
Ford Meter Box Co., Wabash, Ind.
Western Construction & Eng'g Co., Ft. Wayne, Ind.
Bourbon Copper & Brass Works Co., Cincinnati, Ohio.
S. E. T. Valve & Hydrant Co., New York, N. Y.
U. S. Cast Iron Pipe & Foundry Co., Philadelphia, Pa.
Coldwell-Wilcox Co., Newburgh, N. Y.
Golden-Anderson Valve Specialty Co., Pittsburgh, Pa.
James Boyd & Bro., Inc., Philadelphia, Pa.
Boston Talking Machine Co., Boston, Mass.
Modern Iron Works, Quincy, Ill.
Pennsylvania Salt Mfg. Co., Philadelphia, Pa.
Hydro Manufacturing Co., Philadelphia, Pa.
International Steam Pump Co., New York City.
Badger Meter Mfg. Co., Milwaukee, Wisc.
R. D. Wood & Co., Philadelphia, Pa.
The Rickersberg Brass Co., Cleveland, Ohio.
Eddy Valve Co., Waterford, N. Y.

If you manufacture apparatus, machinery or supplies of any kind for use in connection with water supply systems, why not mail a copy of your printed matter to the Promotion Department of **THE AMERICAN CITY,** 93 Nassau Street, New York City, N. Y., and let us make some suggestions which may be of interest in regard to extending your business in the water works field.

To anyone who is not already familiar with our publication we will gladly send a sample copy of

The American City

A Monthly Review of Municipal Improvements and Civic Advance. Our Water Works Department is a very Important Feature.

Does CANADA Convey Possibilities to You?

What provisions have you made for trade

"Across the Line?"

We will be glad to furnish information regarding your chances for establishing *profitable* business in Canada. We will tell you frankly if it can't be done.

When making your plans for Fall Advertising, if you want to reach Canadian Civil Engineers, Waterworks Officials, Municipal Engineers and Engineering Contractors, consult

The Canadian Engineer

Head Office, Toronto, Ont.

London (Eng.) Winnipeg Montreal

Only paper in Canada that conducts a special department dealing with Water Supply, Filtration, Sewerage and Sewage Disposal

"NOT only in recording current methods and undertakings, but also in indicating the lines along which modern industrial and commercial developments may be expected

Cassier's Magazine

fully maintains its plans."

The above is what The Picayune of New Orleans recently stated.

If you do not know

Cassier's Magazine

may we not give you an introduction to it? A request will bring you free sample copy.

Subscription Price $3.00 a Year

SPECIAL SUBSCRIPTION OFFERS

6 months trial subscription - - $1.00
33⅓% saved

3 years subscription - - - - 7.50
16% saved

"Cassier's Magazine is dependable, it retains its integrity in a splendid way."
The Evening Post, Buffalo, New York

The Cassier's Magazine Company
12 West 31st Street, New York

HIGH STANDARDS OF EFFICIENCY
AND HOW TO ATTAIN THEM

THE TWELVE PRINCIPLES OF EFFICIENCY. By Harrington Emerson. A reduction of the doctrine to practice. Emerson discovers twelve principles by which efficiency is determined. They are so definite, so constant, so true, that they may be used as gauges for testing any industry, any establishment, any operation. 12mo, 424 pages, cloth binding, $2.00 prepaid.

EFFICIENCY. By Harrington Emerson. This widely-known book is not the development of a theory, but the statement of principles applied and results attained in practice. 12mo, 172 pages, cloth binding, $2.00, prepaid.

WORK, WAGES AND PROFITS. H. L. Gantt. A complete account of Mr. Gantt's practice in reducing production costs. 12mo, 200 pages, colored charts, 3 folding plates, cloth binding, $2.00, prepaid.

MAXIMUM PRODUCTION (In Shop and Foundry). By C. E. Knoeppel. The machine shop and foundry are considered as twin factors in production, so closely related that their problems can best be studied together. 12mo, 374 pages, diagrams, cloth binding, $2.50, prepaid.

PROFIT-MAKING MANAGEMENT (In Shop and Factory). By Charles U. Carpenter. A concise expression of the methods which Mr. Carpenter constantly uses in his own practice. Sm. octavo, 150 pages, cloth binding, $2.00, prepaid.

PROPER DISTRIBUTION OF EXPENSE BURDEN. A. Hamilton Church. The accurate distribution of general expense is admittedly one of the most perplexing, yet one of the most important, problems with which the manufacturer must deal. 12mo, 120 pages, cloth binding, $1.00, prepaid.

PRODUCTION FACTORS (In Cost Accounting and Works Management). A. Hamilton Church. Mr. Church proposes to avoid the averaging and distribution of expense by percentage and to separate all the important factors of production and reduce them to unit charges. 12mo, 198 pages, diagrams, cloth binding, $2.00, prepaid.

INDUSTRIAL PLANTS (Their Arrangement and Construction). By Charles Day. A synopsis of the whole problem and the practical methods of solving it. 12mo, 294 pages, 48 illustrations, colored chart, 2 folding plates, cloth binding, $3.00, prepaid.

Send for Catalogue of the Standard Books on Organization, Scientific Management, and Equipment.

THE ENGINEERING MAGAZINE CO.
140-142 Nassau Street, New York

ENGINEERING NEWS

Founded 1874

The Leading Engineering Paper of the World

For Engineers, Architects, Draftsmen, Contractors, Manufacturers, Purchasing Agents, Government and Municipal Officials

Stands for progress, character and the highest ideals of the Engineering profession.

Covers the broad field of Engineering more comprehensively than any similar publication.

The most ably edited and most widely quoted technical journal in the world.

Nearly 2000 pages of text, amply illustrated with photographs and drawings, and 450 pages of authentic Construction News notes.

The principal medium for "Situations Open," "Situations Wanted" and "Proposals" advertising.

The Book Reviews in the "Engineering Literature" Supplement and Market Reports in "Current Prices of Engineering Materials" are of great importance to every engineer.

A Subscription is an investment—not an Expense

One Year $5.00

Can You Afford to be Without the Most Important Paper Devoted to Your Profession?

WRITE FOR SAMPLE COPY.

The Engineering News

505 Pearl Street New York City

ENGINEERING RECORD

Water purification is among the most important features of water-works engineering today, and it is asserted without any qualification that Engineering Record has demonstrated its usefulness as a source of early and reliable information on this subject. Plans have already been made for similarly thorough articles in the future, embracing the design, construction and operation of small, as well as large plants.

In the field of water-works construction and operation Engineering Record has long held a unique position in the regard of both superintendents and water boards. The constant endeavor is to maintain the journal's reputation as a necessity in a water-works office.

The design and construction of dams, pumping stations, pipe lines, aqueducts and other parts of a water-works system receive full attention. As an example of exclusive matter of great value may be mentioned the Record's articles on the hydraulic method of constructing earth dams.

Water rates are a subject of much perplexity to engineers, superintendents and commissioners. Appraisals of water-works present related problems. This field of engineering the Record covers comprehensively.

In addition to water-works engineering, the Record comprehends the whole field of civil engineering, including Roads and Pavements, Sewerage, Sewage Disposal and other municipal work; Irrigation and Drainage, Steel, Concrete, Mill Engineering, Hydraulic Plants, Railway Engineering, Waterways, Construction Methods, and Construction News. The Record prints more Proposal advertising than any other civil engineering journal.

$3.00 a Year **Sample Copies Free**

239 WEST 39TH STREET NEW YORK

FIRE AND WATER ENGINEERING

136 West 22nd Street - New York

Established in 1877

THE ONLY PRACTICAL

WATER WORKS JOURNAL

IN THE UNITED STATES

PRINTS THE LARGEST AMOUNT OF IMPORTANT WATER WORKS NEWS EVERY WEEK, including Filtration, Meterage, Litigation, Rates, Pumping and a full epitome of current events in the water works field. . . .

Most complete reports of the water works conventions. . . . . .

Each half-yearly volume contains over 500 pages and numerous illustrations on water works construction and management, making it an important weekly reference book for every water works office. . . . . .

THREE DOLLARS A YEAR

Can You Afford To Be Without The Most Important Publication Devoted To Your Profession?

Can you afford to be without the publication that brings to you *all* the worth while developments in that branch of engineering in which you are so vitally interested today—the design, construction, management, and operation of Water Works Systems?

ENGINEERING NEWS

Should go to *every* engineer who is interested in this problem.

No engineer has time to read *all* the available literature devoted in whole or in part to this branch of his profession, but *every* engineer has time to read the really worth-while developments in this work, as they are compiled and edited in Engineering News.

The most important publication devoted to your profession—How can you afford to be without it?

For 38 years it has been the recognized authority on this and other branches of engineering. Every week it puts you in closest touch with the intimate knowledge and practices, past and present, that vitally concern you in this great work.

Don't put off your subscription. Subscribe Now.

Subscription Price $5.00 Per Year

For 52 numbers, includes postage in the U. S., Mexico, Cuba, Porto Rico, Hawaii, or Philippines.

To Canada, $7.00—To Foreign countries, $9.00 (or its equivalent) including postage.

Sample copy mailed anywhere on receipt of 10 cents postage.

Hill Publishing Company

505 Pearl Street New York

Municipal Journal

Weekly

A. PRESCOTT FOLWELL, Editor

Water Supply is a municipal necessity of the first importance therefore this paper covers it thoroughly.

Its readers are kept posted as to current progress in Design, Construction, Filtration, Purification, Rates, Management, Metering, etc.

It is the aim of the Editor to furnish useful information for those in charge in Water supply, and to express it in plain language, so that non-technical men may understand and use it.

A Complete Index of Current Water Works Literature is Published Every Month

This includes each article which appeared the month before in every publication of any note and gives the title, author, name of publication and date.

It is like having your clerk look through fifty or more papers and make up a list for you.

Isn't that, together with the original matter, worth $3.00 a year to you?

Sample copy upon request.

Municipal Journal

50 Union Square New York

Published for the purpose of creating and fostering friendly relations between the public and public utility corporations

PUBLIC SERVICE

(MONTHLY)

Public utility managers can better care for the *good will* asset by reading and using this periodical

A SAMPLE COPY FOR THE ASKING

H. J. GONDEN, Publisher

Peoples Gas Bldg. Chicago

Water and Gas Review

WATER AND GAS REVIEW is now in its twenty-second year of publication. Its circulation covers almost the entire field of water and gas works practice. Its columns are generally acknowledged to have contained more matter of interest to water works officials than those of any other similar publication. The ablest and most important articles treating of the questions of water supply and water waste which have appeared both in this country and Europe have been printed in its pages. It has been a constant and consistent advocate of the meter system, in the belief that by its adoption everywhere one of the gravest problems confronting the water departments of the country will be satisfactorily solved. A prominent feature of its news columns is the exhaustive publicity it has given, and will continue to give, to legal news affecting the electric, gas and water works interests. The publication of the digest of legal decisions relating to the interest named—compiled from the reports of the United States and State Courts—and the reprinting in its pages of all Court Decisions and Opinions, in full, in the same line—a department not found in any other publication—enhances the value of its files as a source of reference.

SUBSCRIPTION PRICE, $2.00 PER YEAR

WATER AND GAS REVIEW

35 Warren Street **NEW YORK**

All the Difference is in the Nozzle Plug

The only difference between a G-E Recording Water Flow Meter for a 30-inch pipe, and one for a 3-inch pipe, is in the nozzle plug that is inserted in the main. The meter mechanism is the same, and it can be used with either nozzle plug.

G-E Water Flow Meters Can be Installed In Large Pipes At a Small Expense

The long nozzle plugs for large pipes do not cost much more than the short plugs, so that these meters can be used to measure the flow in large mains where the cost of any other type of meter would be prohibitive.

General Electric Company

Largest Electrical Manufacturer in the World

General Office, Schenectady, N. Y., District Offices in

Atlanta Boston Chicago Cincinnati Denver
New York Philadelphia and San Francisco

3497

VENTURI METER BULLETINS

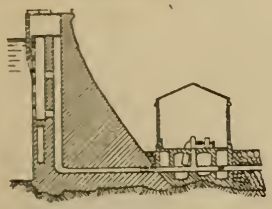
ANY OR ALL WILL BE MAILED UPON REQUEST

Bulletin No. 56. Measuring Water.

By Clemens Herschel.

The first part outlines the various advances made in the methods of measuring large quantities of water. The Second part gives a history of the invention of the Venturi Meter and a discussion of the benefits which have been derived from its use in a number of instances.

72 pages. 13 illustrations. 1 diagram. Size 6 in. × 9 in.

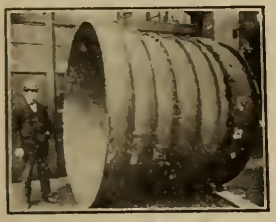


Bulletin No. 71. Special Venturi Meters at the Wachusett Dam.

By E. R. B. Allardice and F. N. Connet.

A reprint of an article published in the *Engineering News*, containing a brief description of an unusual installation of Venturi Meters.

4 pages. 3 illustrations. Size 6 in. × 9 in.



Bulletin No. 72. The Largest Water Meters in the World.

A description of three Venturi Meters on the new Catskill supply to New York City. Reprinted from *Engineering Record* and supplemented by additional illustrations furnished through the courtesy of the Board of Water Supply, New York City.

12 pages. 11 illustrations. Size 6 in. × 9 in.

Bulletin No. 73. "Slip" of Pumping Engines.

A short discussion of the principal causes of "slip" and of the changed conditions under which "slip" occurs, due to the use of modern high-speed Pumping engines. It also shows a photographic reproduction of a worn pump valve.

4 pages. 2 illustrations. Size 6 in. × 9 in.

Bulletin No. 75. The Venturi Meter.

A brief description of its principle of operation, the various uses to which it may be put and the advantages arising from its use. It contains descriptions and illustrations of the various instruments, tables of capacities and other data.

32 pages. 12 illustrations. 2 tables.
Size 6 in. × 9 in.

BUILDERS IRON FOUNDRY

PROVIDENCE, R. I.

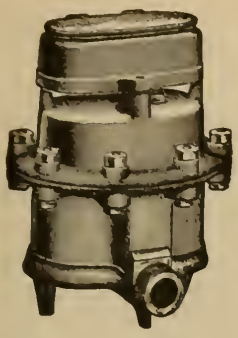
NEW NIAGARA AND AMERICAN WATER METERS

GOOD POINTS

Large Capacity
Adjustment for Pressures
Extra Thick, Strong Disc
Jeweled Bearing Gears
Self-cleaning and Sanitary
Few and Simple Parts
Constancy in Service

WRITE FOR DETAILS AND PRICES

BUFFALO METER CO.
290 TERRACE
BUFFALO, N.Y.
ESTABLISHED 1892



WATER METERS

AND

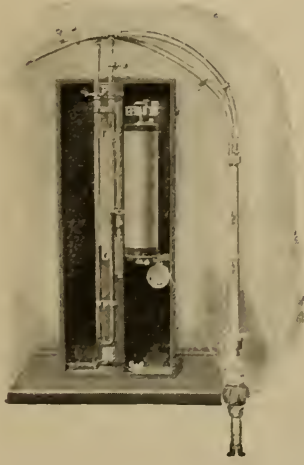
WATER PRESSURE REGULATORS

UNION ROTARY, KING DISK, COLUMBIA AND NILO METERS

UNION WATER METER CO.

WORCESTER, MASS.

Stop the Underground Waste of Water!



American cities waste more water than they use. It is now known that UNDERGROUND leakage is enormous. The PITOMETER is the most efficient Waste Meter known. Adopted by New York City, Washington, D. C., Chicago, etc.

PHOTO RECORDERS
MANUAL RECORDERS
PUMP SLIP INDICATORS

The City of Washington, D. C., has found and stopped underground leakage amounting to over 30,000,000 Gallons daily with our Pitometer. A Saving worth $5,000,000 to the city.

The Pitometer is portable and will accurately indicate or record the flow of water in a pipe of any size, under any pressure, without cutting the main or shutting off the pressure. Only a one inch tap is needed.

We make water waste surveys for cities at a fixed price per million gallons saved or on a per diem basis, as preferred.

We will sell our instruments and help you to organize a Pitometer department of your own, as we have done in Chicago, Washington, New York and many smaller cities.

WRITE FOR INFORMATION

THE PITOMETER COMPANY 220 Broadway, New York

"Watch Dog Water Meters"

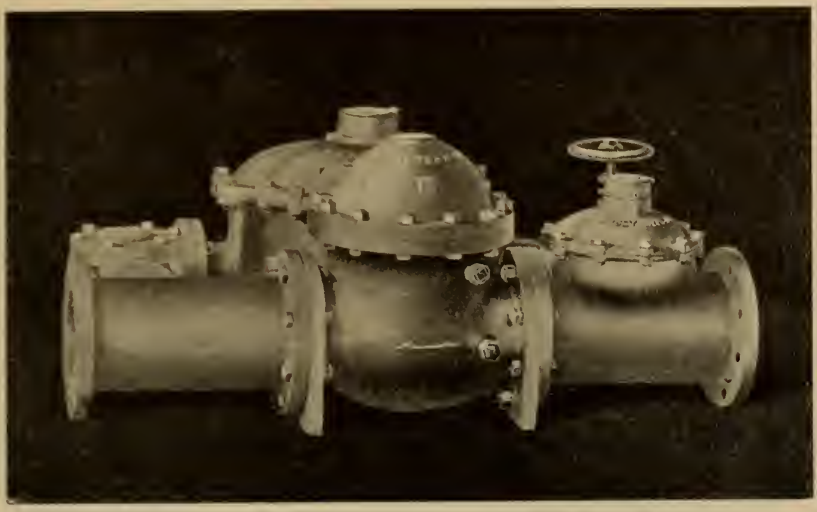
GAMON METER COMPANY

282 to 296 South Street

NEWARK - NEW JERSEY

AS RELIABLE AS THE NAME

ASK ANY ENGINEER



STOP WHOLESALE LOSS

USE THE HERSEY DETECTOR-METER ON FIRE AND MANUFACTURING SERVICES

ENDORSED BY WATER DEPARTMENTS AND UNDERWRITERS

THIS IS THE ONLY METER

WHICH REGISTERS ALL LARGE FLOWS
WHICH REGISTERS ALL SMALL FLOWS
WHICH DOES NOT OBSTRUCT THE FLOW

Send for Catalogue aud also for

BOOKLET CONTAINING TESTIMONIALS OF OVER 70 SATISFIED USERS

HERSEY MFG. COMPANY

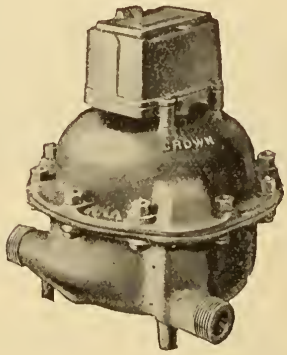
Main Office and Works: South Boston, Mass.

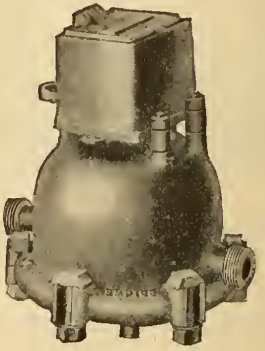
BOSTON, MASS. : 714 Tremont Temple
NEW YORK : 174 Fulton Street
CHICAGO, ILL. : 118 No La Salle St.
COLUMBUS, Ohio : 211 Schultz Building
BUFFALO, N. Y. : 806 White Building
ATLANTA, GA. : National Bank Building

"ALL KINDS OF METERS FOR ALL KINDS OF SERVICES"
400,000 SOLD

QUALITY SUPREMACY

CROWN, EMPIRE, NASH, GEM, PREMIER





WATER METERS

MOST SUCCESSFULLY EMBODY

ACCURACY, DURABILITY, LOW MAINTENANCE COST

PREFERRED THROUGHOUT THE WORLD

NATIONAL METER COMPANY,

Established 1870. JOHN C. KELLEY, President.

84-86 CHAMBERS ST., NEW YORK

CHICAG ·	BOSTON	CINCINNATI
1223 Wabash Avenue	159 Franklin Street	10 West Third Street
PITTSBURGH	SAN FRANCISCO	LOS ANGELES
4 Smithfield Street	681 Market Street	411 South Main Street

LONDON, Caxton House, Westminister, S. W.

TRIDENT WATER METERS

Assembling Simplicity of Trident Construction

The above cut shows a Trident-Disk Meter dismantled and the extreme ease with which it can be assembled, by first putting in the gear train, then the disk-chamber, the frost bottom next, then the register and register box and the meter is complete. The Trident combination wrench is the only tool necessary to use.

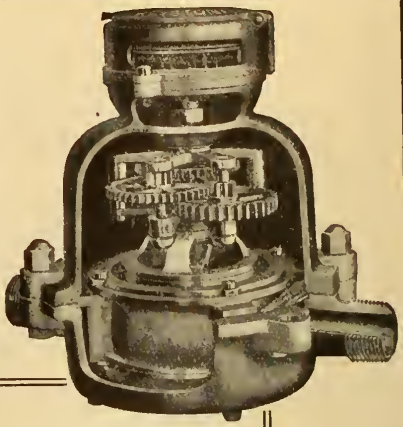
NEPTUNE METER COMPANY

90 WEST STREET NEW YORK

CHICAGO, BOSTON, SANFRANCISCO,
ATLANTA, LOSANGELES, PORTLAND, SEATTLE

KEYSTONE

Water Meters



WE don't ask you to use KEYSTONE Water Meters just because 5000 cities and towns now use them, but

Because,

Authentic records show entirely satisfactory service with low up-keep costs in all these 5000 localities.

Why not give them a trial in your city?

Pittsburgh Meter Co.

Also Manufacturers of Eureka Water Meters, Cast Iron and Tin Gas Meters; Positive and Proportional Gas Meters for any pressure;

General Office and Works: East Pittsburgh, Pa.

New York	Chicago	Kansas City
149 Broadway	337 W. Madison St.	6 W. 10th St.

Columbia, S. C.	Seattle
230 Washington St.	115 Prefontaine Place

LAMBERT

WATER METERS

Long Life.

Lasting Accuracy.

All parts interchangeable.

Maintenance cost nominal.

Their merits have made meter systems popular.

A good article is always worth the price.

All improvements which the tests of time and long service show to be requisite in a **Perfect Water Meter,** are embodied in the **Lambert.**

ONE MODEL ONLY.

Made in all sizes $\frac{5}{8}$" to 6" of best bronze Composition throughout, fitted with Unbreakable reinforced disc-pistons.

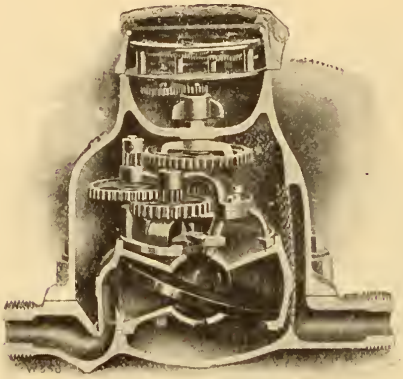
Illustrated Price List on Application.

Address "Dept. I."

THOMSON METER CO.

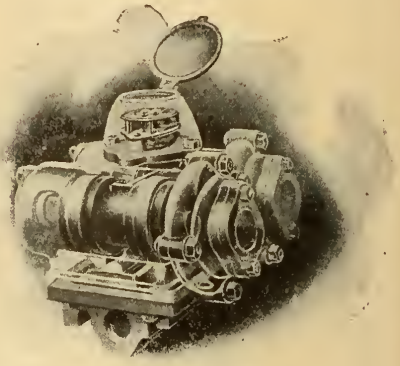
100-110 BRIDGE STREET BROOKLYN, N. Y.

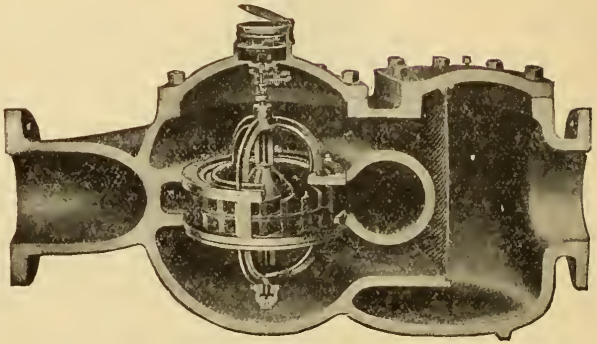
WORTHINGTON METERS



The Worthington Disc Meter combines minimum weight with reliability on constant service and accuracy of registration.

The Worthington Duplex Piston Meter is particularly adapted to large and heavy water works service.





The Worthington Turbine Meter

is designed primarily to handle large volumes of water with minimum loss of pressure

Full descriptions of different types of Worthington Meters, with tables of sizes and capacities, are given in Bulletin W184–59

HENRY R. WORTHINGTON

Works: Harrison, N. J. **New York Office: 115 Broadway**

Branch Offices

Atlanta	Chicago	Denver	Houston	Louisville	Pittsburgh	Salt Lake City
Boston	Cincinnati	Detroit	Kansas City	New Orleans	St. Louis	San Francisco
Buffalo	Cleveland	El Paso	Los Angeles	Philadelphia	St. Paul	Seattle

W. 171.8

H. W. CLARK CO.

118 So. 17th STREET

MATTOON - ILLINOIS

MANUFACTURERS OF THE

"CLARK METER BOX"

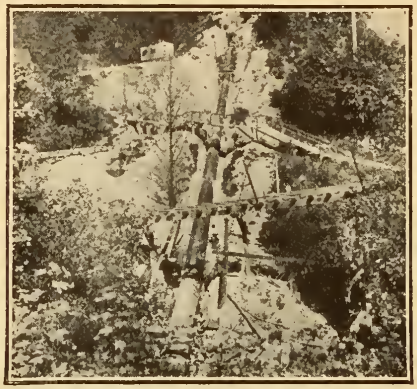
"TEKSAGON"
METER COUPLING

AND MANY OTHER WATER WORKS
APPLIANCES

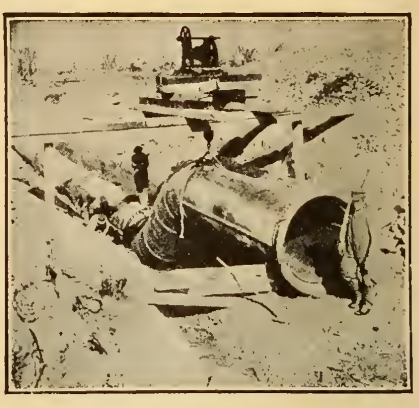
SOLICIT YOUR INQUIRIES

As well as orders for anything in the above line. No order too large nor too small to receive our most careful attention

HAVE YOU OUR LATEST CATALOGUE?



Seattle, Washington
SARCO Mineral Rubber Pipe Coating used on Water-Supply Mains



Denver Water Supply, 48 inch steel pipe protected by SARCO Mineral Rubber Pipe Coating

Mineral Rubber Pipe Coating

is the best protection steel or cast iron pipe can possibly have. This statement is a demonstrated fact. Sixteen years of success proves it. . . Genuine Mineral Rubber Pipe Coating is sold only under the trade mark

SARCO
REGISTERED TRADE MARK

Look for the label on the package. It is your protection as well as ours. Interesting data and specification supplied on request. . .

SARCO
REGISTERED TRADE MARK

STANDARD ASPHALT AND RUBBER CO.

137 SOUTH LA SALLE STREET

CHICAGO, ILL.

American Pipe & Construction Co.

OFFICE

112 North Broad Street

PHILADELPHIA, PENNSYLVANIA

Engineers and Contractors

JOS. S. KEEN, Jr.
President and General Manager

GEORGE M. BUNTING
Vice-President and Treasurer

H. BAYARD HODGE
Asst. Treasurer and Secretary

W. H. ROTH
Asst. Secretary

J. W. LEDOUX
Chief Engineer

JAS. H. DAWES
Superintendent of Construction

HAROLD PEROT KEEN
Superintendent of Operation

Established 1849

W. P. Taylor, Pres. F. J. Abel, Secy. and Treas.

BINGHAM & TAYLOR

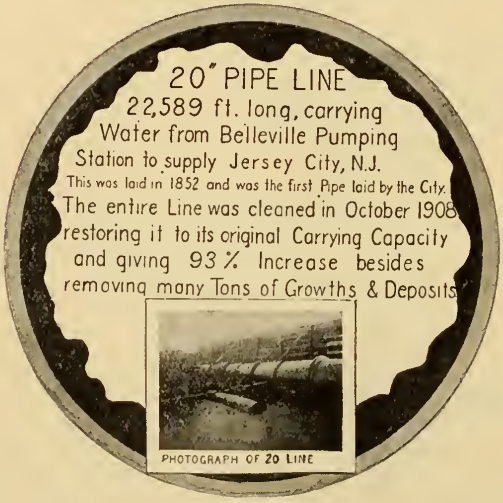
W. P. TAYLOR COMPANY
SUCCESSOR

VALVE and SERVICE SHUT-OFF
BOXES for WATER and GAS

RAILROAD AND GENERAL CASTINGS

Foundry, 575-601 Howard St Office, 218 Ellicott Square

BUFFALO, N. Y.


20" PIPE LINE
22,589 ft. long, carrying
Water from Belleville Pumping
Station to supply Jersey City, N.J.
This was laid in 1852 and was the first Pipe laid by the City.
The entire Line was cleaned in October 1908
restoring it to its original Carrying Capacity
and giving 93% Increase besides
removing many Tons of Growths & Deposits
PHOTOGRAPH OF 20 LINE

We clean pipes large or small.

This illustration shows only one instance among many.

Pipe cleaning is attracting universal attention because it pays.

Apply for further information to

NATIONAL WATER MAIN CLEANING CO.

61 PARK ROW, NEW YORK CITY

MANUFACTURERS AND INVENTORS OF

INVERTED KEY CURB STOPS

IN

MINNEAPOLIS PATTERN

AND

REGULAR DESIGN

WE MAKE CORPORATION STOPS

ALSO

STOP COCKS FITTED WITH LEAD FLANGE TAILS

WE TEST OUR COCKS AT 200 POUNDS

FARNAN BRASS WORKS

CLEVELAND - OHIO

IN BUSINESS SINCE 1852

A SAFEGUARD

AGAINST UNDERGROUND LEAKS

GLAUBER

WATER WORKS BRASS GOODS

GLAUBER BRASS MFG. CO.

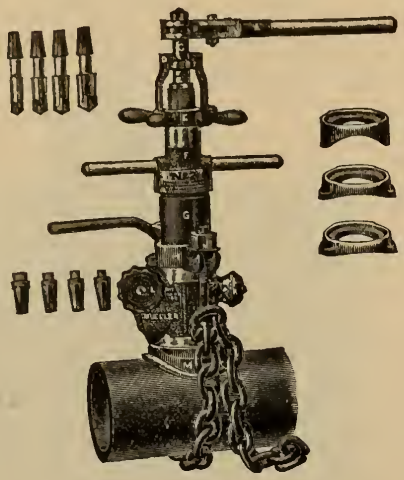
CLEVELAND, OHIO

Quick shipments can also be made from our Branch Offices and Warerooms
44 East 23rd St., New York City and 1107 Mission St., San Francisco, Cal.

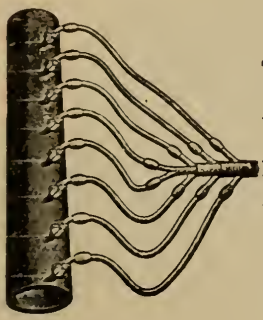
NO. 2 MUELLER

WATER TAPPING MACHINE

Here is a tapping machine as honest as the day is long.

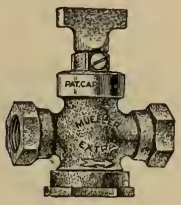


With it you can take out a small corporation cock, plug the hole, or make a larger tap and insert a larger cock or you can remove a plug and insert a cock without shutting off the water.



There is no other machine which will do this. The machine for you is the machine that will do the most things—THAT'S THE MUELLER.

Mueller Curb Cocks and Goose Necks, either regular or lead flange, are preeminent in quality of metal, workmanship or service. Tested under 200 pounds hydraulic pressure and Unconditionally Guaranteed.



H. MUELLER MFG. CO.

DECATUR, ILL.
W. CERRO GORDO ST.

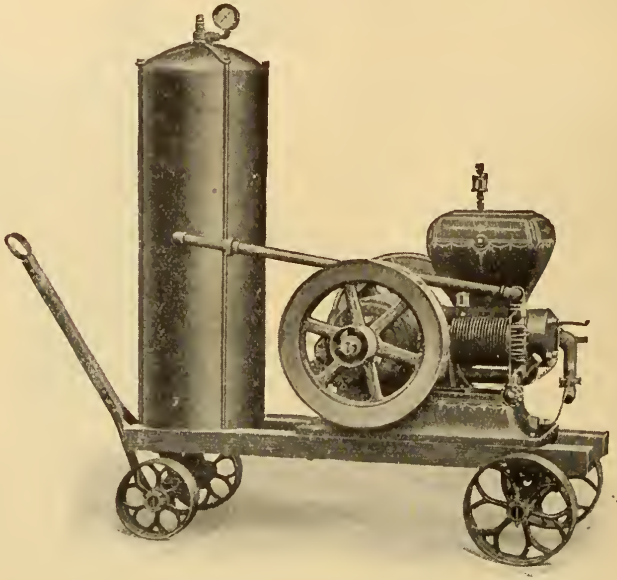
NEW YORK CITY
254 CANAL ST.

THE "SENIOR"

Portable Combination Pneumatic Plant

FOR

Calking Lead Joints in Water or Gas Pipes



This Pneumatic Plant consists of a 5 H.P. Gasoline Engine and Air-Compressor combined in one machine. No belts required. Engine Hopper-Water-Cooled.

We furnish the above Plant, with or without Iron Truck

The above Plant is the most COMPACT and COMPLETE Outfit on the market, and is being used extensively for Calking Lead Joints, Drilling Stone or Concrete, also for Pumping Gas from one vessel to another, Blowing Dust from Electric Generators, Cutting Pipe, Rivetting, Chipping, Tamping, etc., in fact, can be used anywhere that Compressed Air is desired.

THIS IS THE CALKING TOOL

The Calking of Lead Joints by Compressed Air, is the only satisfactory method of to-day, as it saves considerable time and makes a very durable joint. The hand calking of joints cannot be compared to the Compressed Air method.

WRITE FOR PRICES TO

FOSTER & HOSLER

"Pneumatic Outfitters"

431 S. Dearborn St., . . Chicago, Ill., U. S. A.

GRAVITY PRESSURE

FILTERS

EQUIPMENT FOR CONCRETE FILTER PLANTS

OPERATING FLOOR OF FILTER PLANT. BANGOR, ME.

OWNERS OF THE NEGATIVE HEAD FILTER PATENTS

LICENSEES

Pittsburgh Filter Mfg. Co.
Norwood Engineering Co.
Roberts Filter Mfg. Co.

THE NEW YORK CONTINENTAL JEWELL FILTRATION COMPANY

15 BROAD ST., NEW YORK

Originators of Mechanical Filtration

Why Pay Freight on Water?

Our Concentrated Alum, the strongest made, contains over 70% Aluminum Sulfate. ¶Possible only by our Patented Process. ¶We make an Alum for every purpose at the right price ∴ ∴ ∴ ∴

Have You Heard About Our Rust Inhibitive Antoxide?

¶Pipes and Metal Parts protected with Antoxide can't rust. ¶It's the cheapest kind of Insurance. ¶Let ∴ ∴ ∴ us tell you why ∴ ∴ ∴

Harrison Bros. & Company, Inc.

Manufacturers

Chemicals ∴ Paints

Philadelphia

STANDARD FILTER ALUM

HIGHEST QUALITY
LOWEST PRICES
QUICKEST SERVICE

GENERAL CHEMICAL CO.

112 WEST ADAMS STREET

CHICAGO ILLINOIS

SULPHATE OF ALUMINA

AND

"FERRITON"

The Best Coagulants for Water Purification

MANUFACTURED BY

The Jarecki Chemical Co.

CINCINNATI, OHIO

SULPHATE *of* ALUMINA

CHLORIDE *of* LIME

Pennsylvania Salt Manufacturing Co.

PHILADELPHIA, PA.

Illinois Malleable Iron Co.

CHICAGO, ILL.

MANUFACTURERS OF HIGH GRADE

Valve and Service Boxes

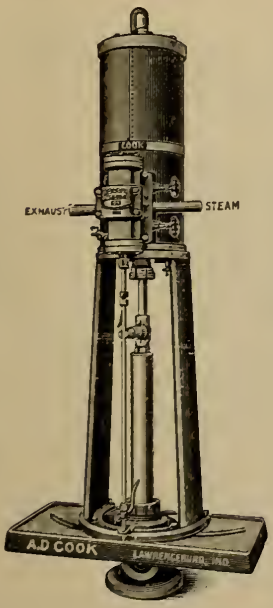
SERVICE BOXES WITH MALLEABLE COVERS—PREVENTING BREAKAGE AND LOSS—CAN BE FURNISHED AT A SLIGHT ADDITIONAL EXPENSE

Malleable and Cast Iron Fittings

Our Malleable Fittings are made of the highest grade of Refined, Air Furnace, Malleable Iron, and have the long tapered, machine reamed thread.

Write for Catalogue

A. D. COOK



LAWRENCEBURG, IND.

MANUFACTURER OF

Steam, Belt and Motor Driven

Deep Well Pumps

AND

Cook's Patent Brass Tube Well Strainer

WRITE FOR NEW CATALOGUE

VALVOLINE OIL COMPANY

CYLINDER
TURBINE
ENGINE
MACHINE

DYNAMO
AMMONIA
SPINDLE
MOTOR OILS
and GREASES

LUBRICATING OILS

STORES

New York Philadelphia Boston Chicago Cincinnati
Charleston, W. Va. St. Louis San Francisco
Los Angeles Portland, Ore.

REFINERIES

Struthers, Pa. Edgewater, N. J. Butler, Pa.

DRAVO-DOYLE COMPANY

PITTSBURGH CLEVELAND
CHICAGO PHILADELPHIA

STEAM TURBINE
AND
MOTOR DRIVEN CENTRIFUGAL PUMPS

COMPLETE WATER WORKS *and* POWER PLANTS

Highest Efficiency

Greatest Economy

Most Modern Construction

at

Reasonable Cost of Installation

MUNICIPAL FILTRATION *and* WATER SOFTENING PLANTS

PITTSBURG FILTER MFG. CO.

Licensees under negative head filtration Patents

1-10

Pittsburgh, Pa.

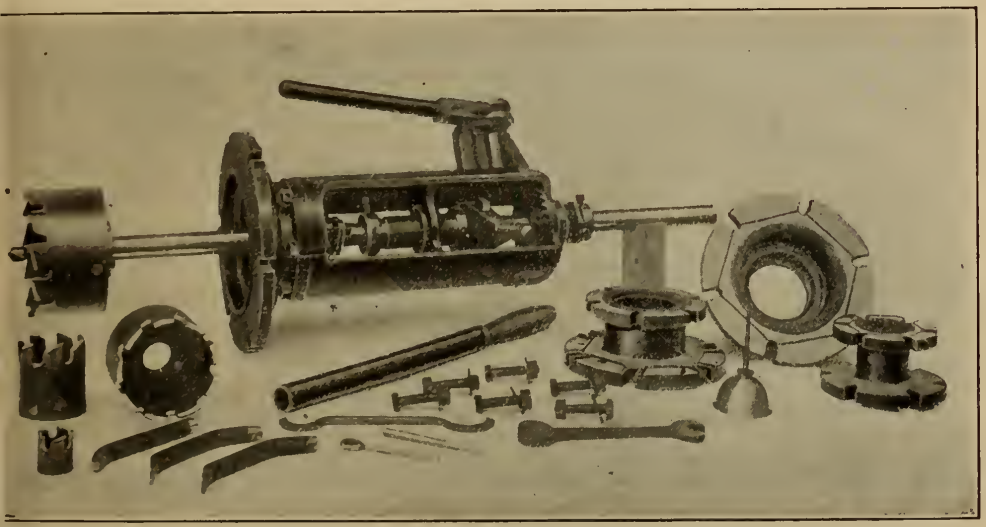
THE A. P. SMITH MFG. CO.

EAST ORANGE, N. J.

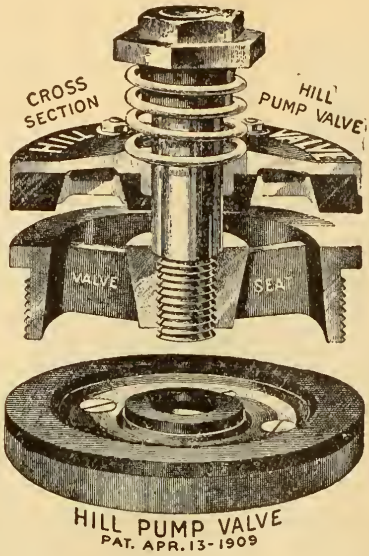
MANUFACTURERS OF

SPECIAL TAPPING MACHINES

For tapping Mains without shutting off the Pressure



Any size cuts can be made, as we have made successfully 20 out of 20, 24 out of 24, 30 out of 30, 36 out of 36, and so on.
The above concern are also supply house for hydrants both high pressure and low pressure, also pipe cutters, valve inserting machines, lead furnaces, meter testing machines, machines for inserting corporation cocks without shutting off the pressure, corporation and curb cocks and general water works supplies.



The Hill Pump Valve

The Valve That Always Stays Efficient

Here is a valve that gives the longest wear and, after the hardest kind of use, is as tight and efficient as the first day you put it in use. It is the only mechanically correct valve. It prevents slippage—cannot warp or ride on the bridges of the valve seat—saves steam consumption and thereby decreases the cost of operation. The Hill Pump Valve eliminates the expense caused by frequent shut downs to renew valves. It not only maintains, but actually *increases* the efficiency of any pump—at less cost.

Guaranteed

The Hill Pump Valve is backed by the broadest guarantee we can make. Our business reputation and every penny of our capital is behind it.

Write for Information and Price

It will pay you to find out definitely about the Hill Pump Valve today. Ask us for proof and names of big users.

Hill Pump Valve Company

20 E. KINZIE STREET . . . CHICAGO

BRANCH OFFICE: 90 WEST ST., NEW YORK CITY

Responsible Representation Solicited

JAMES M. CAIRD

Asso. Am. Soc. C. E.
271 RIVER ST., TROY, N. Y.

Chemist and Bacteriologist

:: WATER ANALYSES ::

SPECIALTIES—Tests of Filter Plants; Examinations and Reports upon Proposed Sources of Water Supply; the Copper Sulphate Treatment for Algae; Expert Testimony

---

JOHN W. ALVORD — CHAS. B. BURDICK

CONSULTING ENGINEERS

Water Supply — Sewerage — Water Power

HARTFORD BUILDING · CHICAGO

Water examination and reports upon new supplies, tests of filter plants for efficiency, treatment of supplies for purification and elimination of Algae troubles, tests of sewage disposal plants.

BULL & ROBERTS

100 MAIDEN LANE NEW YORK CITY

Water Analyses (chemical and bacteriological) Sewage examination

Chemical and Physical Tests of Cement, Concrete, Coal, Oil (road, lubricating and fuel) Bricks, etc.

Water Supply — Water Purification — Sewerage — Sewerage Disposal

WM. G. CLARK

Consulting and Sanitary Engineer

1048-9 and 50 Spitzer Bldg. TOLEDO, OHIO

WILLIAM R. CONARD

Assoc. Amer. Soc. C. E.
Assoc. Mem. Amer. Soc. M. E.

Inspection and Tests of Materials

SPECIALTIES

Water Works Supplies, Pipes, Valves, Pumping Machinery, Etc.

322 HIGH STREET, BURLINGTON, N. J.

Mem. Amer. Soc. C. E. | Mem. Am. Inst. M. E. | Mem. Am. W. W. Asso.
L. D. Phone 1201 Gran. | CABLE ADDRESS, ROLYAT, PITTSBURG, PA.

SAMUEL A. TAYLOR, C.E.

Consulting Engineer

8th Floor, Lewis Building — PITTSBURG, PA.

Special Attention Given to Reports on Water Works, Coal and Coke Properties, Etc.

GEORGE W. FULLER

Consulting Hydraulic Engineer and Sanitary Expert

Water Supply and Purification, Sewerage and Drainage, Disposal of Sewage and Refuse, Investigations of Epidemics, Water Works Valuations, Supervision of Construction and Operation

Associates JAMES C. HARDING, JAMES R. McCLINTOCK — 170 Broadway, New York City

---

Water Works — Power Plants — Sewerage

Reports, Designs, Superintendence, Tests, Appraisals

DABNEY H. MAURY

Mem. Am. Soc. C. E. — Mem. Am. Soc. M. E.

CONSULTING ENGINEER

1137-8 MONADNOCK BLOCK — CHICAGO, ILL.

Sewerage and Sewage Disposal. Water Supply and Purification. Water and Electric Power

ALEXANDER POTTER, C. E.

HYDRAULIC ENGINEER AND SANITARY EXPERT

50 Church Street — NEW YORK CITY

Valuation of Existing Plants where MUNICIPAL OWNERSHIP is Contemplated—Plans and Estimates—Supervision

---

CLYDE POTTS,

M. Am. Soc. C. E.

Civil and Sanitary Engineer

30 CHURCH ST., NEW YORK

Sewerage and Sewage Disposal. Waterworks and Water Supply Reports, Plans and Estimates

---

PROVIDENCE, R. I. — 86 WEYBOSSET STREET

Edmund B. Weston

CONSULTING ENGINEER

Member of the American Society of Civil Engineers

Member of the Institution of Civil Engineers of Great Britain

WATER SUPPLY, FILTRATION OF WATER, FIRE PROTECTION, MUNICIPAL WORK

WATER PURIFICATION SEWAGE DISPOSAL HYGIENIC ANALYSES

Robert Spurr Weston
M. Am. Soc. C. E.

CONSULTING SANITARY ENGINEER

14 Beacon Street Boston, Mass.

Member { A. S. M. E. / A. S. C. E. / A. I. E. E.

Consulting Engineer and Operator for Public Utilities Properties

W. B. YEREANCE

Plans, Construction, Management; Valuation, Rate, Operating Efficiency, Betterment and Investment Reports. Project Investigations and Designs for Efficient Combined Plants .·.

128 BROADWAY NEW YORK

THOS. FORD, Prest. P. BARDO, Treas.

THE BOURBON COPPER & BRASS WORKS CO.

Manufacturers of Fire Hydrants, Stop Valves and Extension Valve Boxes, Bourbon "Open and Shut" Indicator Post.

No. 618-620 E. FRONT STREET CINCINNATI, OHIO

Long Distance Phone Canal 3297 Write for 1912 Catalogue

POSITIONS WANTED

If in need of water works superintendent or manager, apply to the secretary of the Association. There are on file in this office the applications of several members of the Association.

Members of the Association desiring positions will please file their applications with the secretary of the Association.

Members in writing to advertisers will confer a favor on the Association by mentioning the fact that they saw the advertisement in the Proceedings of the Association.

YOU CAN MAKE

Any Reservoir leak-proof, waste-proof, waterproof by specifiing "PIONEER" RESERVOIR WATER-PROOFING ASPHALT. No matter what climate you are in—no matter what extreme temperature conditions must be met—"PIONEER" will meet the requirements. It has never failed to do so.

"PIONEER"

Reservoir Waterproofing Asphalt

is elastic and insures against the breakage of the waterproof stratum on account of the settling of a concrete structure. It has been specified exclusively for many years by hydraulic engineers of the highest standing.

If interested in the integral method of waterproofing write for booklet No. 541, describing "STERLING" WATER-PROOFING PASTE and other damp-proofing and water-proofing materials.

The American Asphaltum & Rubber Co.

Harvester Bldg., Chicago

YOU CAN SAVE

Money for your city—any city—on any steel pipe line construction anywhere—by specifying "PIONEER" MINERAL RUBBER PIPE COATING for the permanent preservation of the pipe. "PIONEER" adheres tenaciously to the metal, yields to expansion and contraction, is unaffected by acids and earth salts, is non-conductive and will withstand electrolytic action.

"PIONEER"

Mineral Rubber Pipe Coating

Has a 16-year record. It has been used on nearly every important steel pipe line construction in this country. It is endorsed by foremost engineers and as one firm says "it has always given satisfaction because of its preservative and protective qualities." Specifications and data on request.

Opposite page refers to our "PIONEER" RESERVOIR WATERPROOFING ASPHALT (membrane method). If interested in the integral method of waterproofing write for booklet No. 541—"STERLING" WATERPROOFING PRODUCTS.

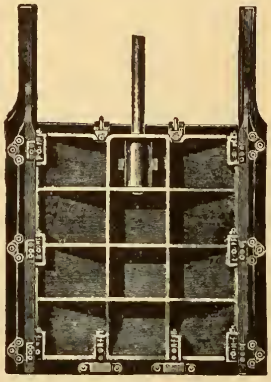
The American Asphaltum & Rubber Co.

Harvester Bldg., Chicago

SLUICE GATES

ALL STYLES AND SIZES

Hand, hydraulic and electric hoisting mechanism



COLDWELL-WILCOX CO.

12 RIVER STREET

NEWBURGH, N. Y.

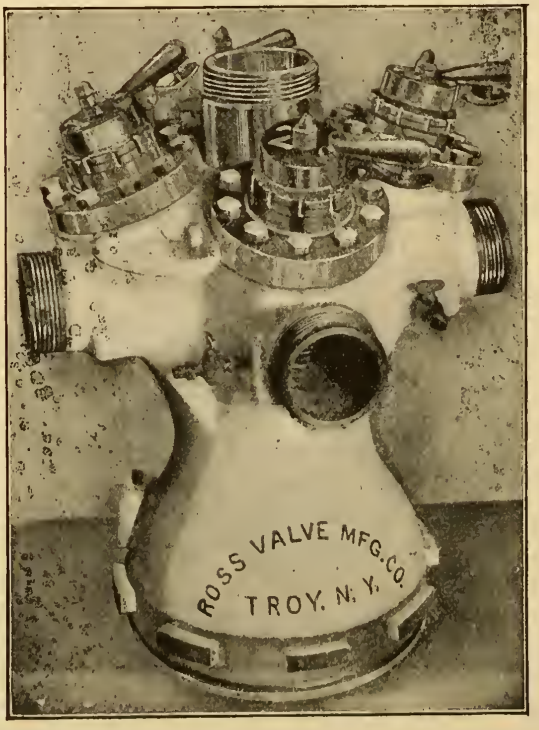
AMERICAN CAR AND FOUNDR COMPANY

BERWICK, PENNA.

Bell and Spigot Fittings, American Water Works Association Standard

FLANGE PIPE

FLANGE FITTINGS



HIGH PRESSURE SPECIALTIES

"VULCAN" PORTABLE FIRE HYDRANT HEAD

TROJAN REGULATORS FOR FIRE STREAMS

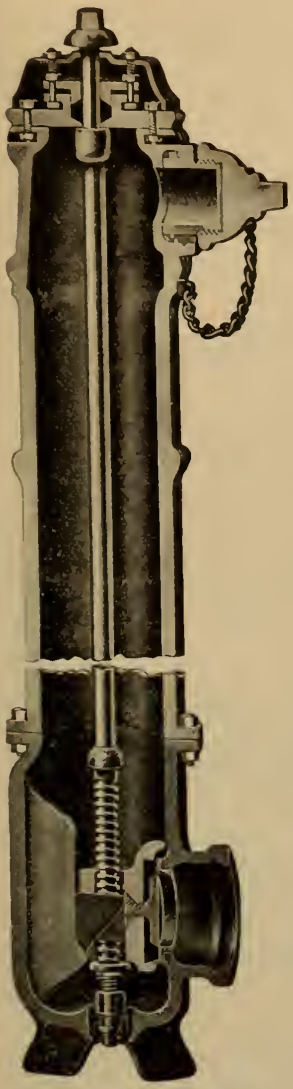
Pressure Regulators and Relief valves for Air, Steam or Water

Send for List of Users

Ross Valve Co.

Troy, N. Y.

THE LUDLOW VALVE
MANUFACTURING CO.
TROY, N. Y.



Slide Gate Hydrant with Patented Gate Locking Device

GENUINE
LUDLOW
GATE VALVES

Slide Gate and Balanced Valve
FIRE HYDRANTS

SLUICE GATES

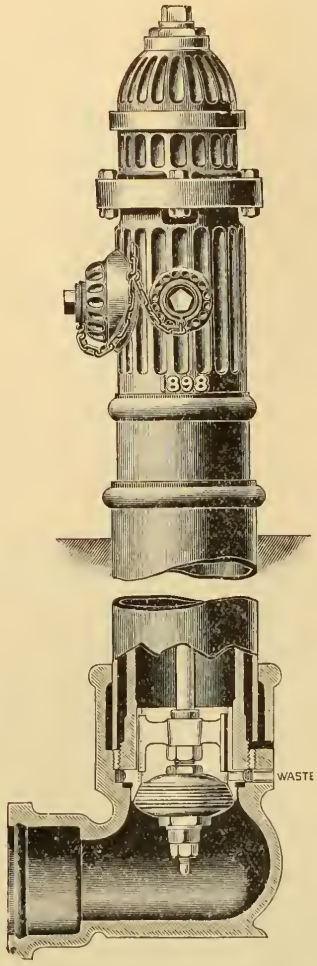
CHECK VALVES
FOOT VALVES
INDICATOR POSTS

BRANCH OFFICES

NEW YORK, 62 Gold Street
BOSTON, 141 Milk Street
PHILADELPHIA, Harrison Building
CHICAGO, 633 The Rookery
PITTSBURG, Farmers Bank Building
KANSAS CITY, Victor Building

R. D. WOOD & CO.

400 Chestnut Street, Philadelphia, Pa.



MATHEWS

SINGLE AND DOUBLE VALVE

Fire Hydrants

GATE VALVES

INDICATOR POSTS

CHECK AND FOOT VALVES

CAST IRON PIPE SPECIALS

Hydraulic Machinery

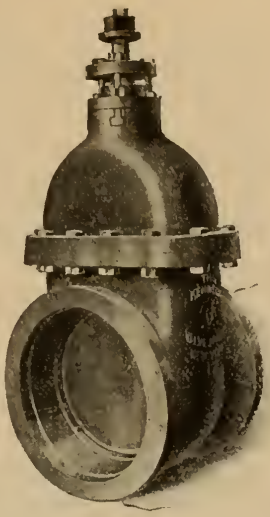
GAS HOLDERS

Pumping Machinery, Sugar House Work

Gas Producer Power Plants

The Scientific Principle of a few parts whose united action make for efficient service is the principle of the

"NEWTYPE"
Water Gate Valve



Has Double Wedging Mechanism of solid bronze (preventing stem binding or bending). Parallel seats (assuring tight joints and eliminating leakage) and Independent Stem Nut. The straightaway passage is the full diameter of the connecting pipe. For full description write us for our CATALOG.

Think of a Frost-Proof Hydrant!

The special double drip-valve in the "Newtype" Fire Hydrant draws off all water in the standpipe. Always closed when hydrant main valve is open and open when valve is closed—automatic in action. Furthermore, should the "Newtype" Hydrant be broken it will not flood, the valve being kept closed by main pressure. All parts easily accessible for any repairs, without digging up. Write us for literature.

The Kennedy Valve Mfg. Co.

1022 E. Water Street

ELMIRA, N. Y.

BRANCH OFFICE AND WAREHOUSE

51 Beekman Street **New York City**

AGENCIES

660 Western Union Building
Chicago, Ill.

622 Bessemer Building
Pittsburgh, Pa.

The COLORADO FUEL & IRON CO.

DENVER COLORADO

Manufacturers of Cast Iron Water and Gas Pipe and Specials

Manufacturers of Smelting and Foundry Coke, also of Rails and Fastenings, Wire Nails, all kinds of Plain and Galvanized Wires, Barbed Wire Fencing, Painted or Galvanized, Field Fence, Poultry Netting, Iron or Steel Bars ∴ ∴

Miners and Shippers of all the best grades of

COLORADO COAL

CAST IRON PIPE

ALL REGULAR SIZES
3 INCHES TO 84 INCHES

For WATER, GAS, SEWERS, DRAINS, Etc.

SEND FOR STANDARD SPECIFICATIONS

Railroad and Turnpike Culverts
Flange Pipe and Flange Fittings

HEAVY CASTINGS

AND THOSE MADE FROM ORIGINAL DESIGNS

United States Cast Iron Pipe and Foundry Company

GENERAL OFFICES, BURLINGTON, N. J.

General & Eastern Sales Office	1421 Chestnut St., Philadelphia
Western Sales Office	923 Peoples Gas Bldg., Chicago
Southern Sales Office	James Bldg., Chattanooga
N. Y. Sales Office	71 Broadway, New York
Pittsburg Sales Office	Henry W. Oliver Bldg.
St. Louis Sales Office	520 Security Bldg.
San Francisco Sales Office	799 Monadnock Bldg.
Portland Sales Office	621 Yeon Bldg., Portland, Ore.

CHARLES MILLAR & SON CO.

MAIN OFFICE, UTICA, N. Y.

BRANCH OFFICES

176 Federal Street
Boston, Mass.

150 Nassau St., New York City
Story & Stephens

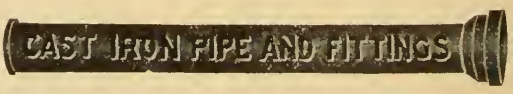
CAST IRON WATER AND GAS PIPE

AND SPECIALS

Cast Iron Flanged Pipe, Cast Iron Soil Pipe and Fittings and Screwed Steam Fittings, Pig Lead, Lead Pipe Solder and Metals and Sewer Pipe, Jobbers in Plumbers', Steam Fitters' and Mill Supplies

AMERICAN CAST IRON PIPE CO.

MANUFACTURERS OF



FOR

WATER, GAS AND CULVERTS

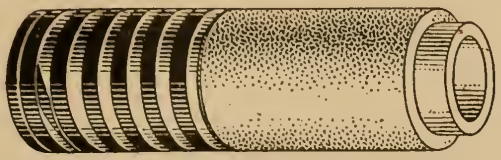
General Offices and Foundries

BIRMINGHAM :: ALABAMA

Sales Offices

716 Scarritt Bldg., Kansas City, Mo.
461 Market St., San Francisco, Cal.
416 Praetorian Bldg., Dallas, Texas
No. 1 Broadway, New York
BIRMINGHAM, ALABAMA

Wood Water Pipe Has Stood The Test of Time



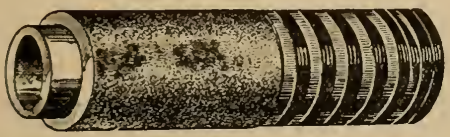
DURABILITY Let us submit *proof* of wood water pipe in service 50 years and still in use.

The cost of the pipe is only the first step in the saving effected. The amount saved is appreciable. Can we show you? **ECONOMY**

Write for Catalog

EASTERN MANUFACTURING CO.

557-699 Clinton Street ELMIRA, N. Y.



STANDARD
WOOD PIPE CO.
WILLIAMSPORT . . PENNA.

We manufacture WOOD PIPE especially for Water Works Systems, Municipalities, Mining, and Railroad Water Works, etc.

We know that quality, prices, and information on our WOOD PIPE will assist you in making up your estimates.

WRITE FOR OUR BLUE BOOK.

THE CHAPMAN VALVE MANUFACTURING CO.

INDIAN ORCHARD - MASS.

TD
201
A512
1912

American Water Works
Association
Proceedings

[redacted]

Engineering

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE